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Alfred Herbert Tubby

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The Journal of Bone and Joint Surgery

The Journal of
Bone and Joint Surgery

EDITORIALS AND ANNOTATIONS

THE TREATMENT OF BONE SARCOMA

The results of treatment of bone sarcoma either by surgery or by radiotherapy have in the past been so disappointing, that any analysis of cases which may throw some light on this gloomy subject is more than welcome. One of the greatest difficulties in assessing the results of treatment arises from the small numbers of cases which an individual surgeon or radiotherapist sees and treats; and if any progress is to be made some form of Central Bone Tumour Registry is imperative. Bristol deserves commendation for the establishment of a Bone Tumour Registry which has made possible the publication in this issue of a report by Dr R. C. Tudway of the place of external irradiation in the treatment of osteogenic sarcoma.

The main points of interest which emerge from Tudway's report are a plea for the use of Price's method of grading of osteogenic sarcomata; the description of an atypical group of osteogenic sarcomata which simulate, at least in the early stages, an inflammatory condition of bone, but which have a good prognosis; the poor prognosis of the osteolytic as compared with the osteoblastic type; the influence of age on prognosis, and a plea in selected cases for irradiation of bone sarcoma to be followed by local resection. These are all, of course, controversial points, not least of which is the last.

Price's method of grading osteogenic sarcomata has the merit of simplicity, and its value is well borne out by Tudway's series of cases. It is based on the Mitotic Ratio which is defined as the ratio of the total number of cell nuclei counted to the number found to be in mitosis, and three grades are described. Grade I—mitotic ratio greater than 400 to 1; Grade II—mitotic ratio between 400 to 1 and 100 to 1; and Grade III—mitotic ratio less than 100 to 1. It is obviously a method of grading which deserves a very extended trial, but it does conflict with the considered opinions of other competent pathologists. Professor Scarff has stated the view that " with growths in many other situations histological appearances and behaviour have been adequately correlated, the main factors favouring malignancy being de-differentiation and evidence of rapid growth such as hyperchromatism and mitosis. An analysis of osteogenic sarcoma from this point of view does not show this correlation and those cases which are successfully treated, whether by surgery or irradiation, frequently show evidence of very rapid growth, whilst apparently well differentiated slowly growing tumours may behave with extreme malignancy." All of Tudway's five-year survivals were examples of Grade I.

The atypical group of cases is not a well defined group. They are atypical only because they do not exhibit sun-ray spicules and Codman's triangle, and these should never be the sole radiological criteria of bone sarcomata. In Figure 8 there is evidence of new bone formation, cortical expansion and destruction, and perhaps soft-tissue invasion. A guess might be hazarded that the better prognosis of the " atypical " type was due in Cases 10, 11 and 12 to encapsulation of the tumour. It would be unfortunate if the term atypical came to be applied to a bone sarcoma which had not yet burst forth from its tissue of origin.

The eight cases of osteolytic osteogenic sarcoma shown in Table I were with one exception—Case 8—very inadequately treated. That there are technical difficulties in irradiating tumours of the ilium will be readily agreed when the available kilovoltage does not exceed 200 kilovolts, but only three of the eight cases were thus situated. It is interesting

in this connection to recall that Platt recorded no survivals in the sclerosing type, and five five-year survivals in the osteolytic type with surgery alone.

Sarcoma arising on Paget's disease of bone has a uniformly fatal prognosis, and the presence of pre-existing bone conditions in the older age groups obscures the influence of age on prognosis. Age alone in the absence of Paget's disease is, however, no contra-indication to radical treatment.

On the basis of two patients (Cases 13 and 14) who have survived twenty months and two years respectively following irradiation and local resection, it is perhaps a little naïve to suggest an extended trial of this method. Though the cure rate from amputation is bad it is at least pertinent to remark that in Tudway's own series three out of four patients surviving for more then five years underwent amputation. In this series of cases 12·1 per cent survived for five years, which is comparable with the best figures that have so far been published. In the large series of 118 five-year survivals reported from the records of the American Registry of Bone Sarcoma, twenty-one of which were chondrosarcoma, ninety-seven survivors out of a group of 654 who had been treated five years previously or longer, gave a five-year survival of 14·8 per cent. Platt's series of 161 cases of bone sarcoma of all types including chondrosarcoma showed twenty-three survivals over five years. Osteolytic osteogenic sarcomata account for five of these twenty-three cases, and if one includes six cases of extraperiosteal sarcoma which would probably have been included in the American series this gives eleven five-year survivals. As an approximation it would seem reasonable to assume the same overall distribution of osteogenic sarcoma as in the American analysis of uncured cases, namely 40 per cent, which would give Platt a five-year survival rate of 17 per cent. Platt's five-year survivals in all types of bone sarcoma with surgery alone is twenty-three in a total number of cases of 161, or 14·3 per cent.

Coley and Harrold from the Memorial Hospital, New York, report fifty-nine five-year survivals in a total of 252 cases, or 23·5 per cent, but thirty-six of these patients were irradiated as well, and many were treated with bacterial toxins. The post-operative treatment with toxins has been abandoned and so also since 1940 has pre-operative irradiation, so that a comparable series without irradiation should soon be available. A comparison of Platt's figures with those of Coley and Harrold suggests that a prima facie case might be made for surgery plus irradiation. Coley and Pool report a five-year survival rate of 22 per cent and state that the histological grading of the tumour is of value in estimating prognosis.

Comparisons between various series is difficult and cases of chondrosarcoma probably creep into most series of osteogenic sarcoma, but enough has been published to show that at least four out of every five patients do not survive five years. To improve the survival rate it would seem not unreasonable to test the value of higher pre-operative doses of deep x-rays. No definite evidence of the value of pre-operative irradiation can be adduced from previously published figures, but at least it has not been shown to have a deleterious effect. Connective-tissue tumours are in the main radio-resistant, but this is, as Cade has pointed out, a relative term—there is no absolute radio-resistance. All tissue can be destroyed if the dose given is high enough—pre-operative irradiation to a much higher dosage level than has been given previously and amputation before the effects of overdosage become apparent might be expected to improve prognosis. Doses of 1,000r daily for ten consecutive days can safely be given without producing any systemic upset in the case of limb irradiation. Amputation can be undertaken immediately after the course of irradiation or within a week. It is unlikely that evidence of radionecrosis will become apparent for several weeks. No pre-operative therapy will deal with cases which have metastasised to the lungs before amputation, but the appearance of radiological evidence of lung secondaries during the period of a few weeks after many amputations suggests that amputation may in some cases actually precipitate metastases. All neoplastic cells which become disseminated by the blood stream do not eventually become metastases. Some may die in the circulating blood and others at the site

of implantation or arrest, and again others become progressive metastatic lesions which ultimately cause death. Pre-amputation irradiation to a high level can be expected to reduce the viability of tumour tissue which is detached subsequently. It is on these lines rather than by local resection following irradiation that improvement in the survival figures is likely to occur.

W. SHANKS.

INERT PROSTHESES IN RECONSTRUCTIVE SURGERY

Whatever one may think to-day of man as a political animal there is no doubt that in the scientific field we live in challenging and intensely exciting times. The nuclear physicist has made the philosopher's stone distinctly "*vieux jeu*" and the ability of the chemist to "tailor" molecules to suit his own ends is no longer a mere pipe dream. Since generations of surgeons have deplored the deficiencies of human tissues as engineering media (and, be it admitted, often paid insufficient respect to their adaptive advantages) it is in no sense surprising that orthopaedic surgeons in particular have, ever since the advent of aseptic techniques, panted at the heels of these and other basic researchers. Already we make free with their products, and implant them happily where we will. We are borrowing their methods and by tomorrow the Geiger counter may be telling us when to act. More, our role is subtly changing from that of mere hangers-on to that of directors. We ask a chemist for a new plastic of such and such properties which will behave thus and so, and are taken quite seriously. It is a sobering thought (or exciting, according as one may regard it) that were we not forbidden to advertise we might today be announcing not only that "We fix flats" but that we have an "Authorised Spares Service." A "Lubrication Service Bay" in the orthopaedic department seems but a step away.

This simile constitutes an Awful Warning and its choice is deliberate. We are all saddened by the "garage-minded" patient who is perplexed and maybe a little hurt because he cannot understand that our offer to operate upon his troublesome joint does not mean a complete rebushing with a written guarantee of so many thousand miles of painless transportation. The first step into peril—who has not taken it?—is to try to explain in his vocabulary and ascribe his arthritis to wear and tear and liken his crepitant joint to a cracked bearing. In no time we begin to think in his terms, and when, as now, we can literally reach out and take a spare out of the rack we are on the slippery slope indeed. We *must* remember physiology and pathology. We must not qualify for membership of the A.E.U.

Authoritative reviews of "The Snags" therefore were probably never more necessary than they are today, and the review of complications and difficulties of the Judet arthroplasty by St J. D. Buxton and W. Waugh in this issue is as welcome as it is timely. That the complications they review are mainly mechanical derives from the fact that their series, though long, is a young one (two years) and not from any "garage-mindedness" in the authors. Wisely they reserve consideration of function to a report, in due course, of later results, which will assuredly tell us, directly or indirectly, much more of physiology and pathology.

Despite the pitfalls, however, that lie thick about us, to fail to recognise that joints and their motors are, after all, mechanisms and locomotion a mechanical process, is as faulty an approach as the over-mechanical. In addition there is a trap for us half way, for it is not very much use accepting an engineering approach with the reservation that living tissues will react to and modify our mechanics, and then being daunted because the result is not an affair of close tolerances. The majority of internal prostheses would give a precision engineer a fit of the horrors and it is well to remember this. Inert prostheses will not unite with living tissues (some protein plastic may yet alter this) and therefore we must strive for precision especially in disposing them appropriately to lines of force so that they do not rock loose. But provided our mechanism works and its parts, living and inert, endure, we need not be

unduly put out if the prosthesis itself rocks like a mad thing or spins like a top, in its socket. All this is not, however, to deny that the less it rocks or spins the better. Already we are well provided with inert substances, at least among those that are hard (flexible prostheses are a comparatively unexplored field). In the case of the hip we have forged ahead, but do we really know all we should about the transmission of weight through this joint, and where, therefore, the stem of any prosthesis should lie to be under minimal strain? What is the answer to the complete lack of inherent stability in the bone structure that we may wish to replace in the knee? When is it fair to the patient to cease striving for healing and to cut our losses in favour of an artificial substitution?

There are formidable questions to be answered; so, though it needs no unique imagination to enumerate the criteria of a good prosthesis, it may be not inappropriate to rehearse them here. First the substance must provoke no harmful reaction. Second, its introduction into the body must be a reasonable as well as a reasoned procedure. Third, it must work. Fourth, fifth and sixth—all implicit in third—it must endure sufficiently, its living surroundings must endure equally, it must stay reasonably "put." Seventh, its failure must not leave an irretrievable situation.

With these criteria before us there seem few limits to what may be possible. The Judet prosthesis, its derivatives, and the vitallium mould, are prostheses essential for normal or nearly normal function in the hip. The artificial radial head described in this issue by J. C. Cherry of Dublin seems already to merit the epithet "desirable" and may progress to being regarded as essential. Further news of this procedure will be eagerly awaited.

The transplantation of a complete fresh cadaveric femur to replace one riddled with hydatid disease, described by Capurro and Pedemonte of Montevideo, is indeed an heroic measure. It remains to be seen whether this mass of bone can be fully reconstituted as a living structure. If so, we can indeed begin to look about us, albeit with the reflection that some inert gadget may prove necessary at each end of such transplants.

Our ophthalmic colleagues already employ acrylic lenses, while others wrestle with artificial kidneys, hearts and gullets. Where do we go from here? Scarcely can one forbear to cry, "*En avant, mes braves!* Forward! Excelsior!" or similar exciting phrases. I wonder whether the sotto voce aside, "with certain criteria in mind!" would spoil the clarion call?

O. J. Vaughan-Jackson.

PROBLEMS OF MATERIALS IN BONE REPLACEMENT

Reports by St J. D. Buxton and W. Waugh, by J. C. Cherry, and R. G. Capurro and P. V. Pedemonte in this issue of the Journal are of considerable interest, as they illustrate developments in orthopaedic surgery. Buxton and Waugh, and Cherry, have used a synthetic material while Capurro and Pedemonte have employed human cadaveric bone to replace part of the skeleton. Both materials have problems associated with their use, the most important being biological compatibility—or the physiological response of the host to the implant. This response, which may be immediate or delayed, malignant or benign, is dependent on the chemical and physical properties of the implant.

The use of entire human bones to replace parts of the skeleton is a logical advance, considering the satisfactory results achieved with homogenous bone grafts. There is little doubt that implanted bone once removed from its blood supply dies and subsequently behaves as a foreign absorbable material. It does, however, form a scaffolding and is probably also an osteogenic stimulant. The formation of a new bone involves the revascularisation and absorption of the implant which, of necessity, must be a long process. The body's response to such a large mass of dead material is difficult to predict. It is likely that osteoarthritic changes will take place in and around the acetabulum and tibial plateau just as they often occur in the hip with avascular necrosis of the head of the femur after fracture of its neck.

Over the last few years a number of reports have appeared on the use of non-absorbable synthetic materials or plastics employed as bone replacements. Plastics are synthetic resins of high molecular weight and are divided into two groups, thermosetting and thermoplastic. The simple chemical units from which the plastics are formed by polymerisation or condensation are themselves sometimes irritant. The synthesis of plastics is often brought about by catalysts, or by accelerators or by both. Other substances such as fillers, pigments, plasticisers, anti-oxidents, and stabilisers may be added for a variety of reasons. While the resin itself may be inert, the addatives may leach out of the plastic and be cytotoxic. A great range of materials having a wide diversity of properties is available. A large number of these plastics are unsuitable for surgical purposes. The assessment of the remainder takes a considerable time, short term animal experiments being of little value. Three groups of materials, all thermoplastics, appear on the whole to be satisfactory—polyethylene (Alkathene), polymethyl methacrylate (Perspex, Lucite, Plexiglas) and polyamides (Nylon). Even with these materials there have been reports of tissue reactions; for example, Poppe and Oliveira (1946) found that polythene film produced a marked fibrous tissue proliferation, whereas Ingraham, Alexander and Matson (1947) and others reported negligible response. Yeager and Cowley (1948) investigated these conflicting reports and discovered that, whereas pure polythene film was inert, the samples investigated by Poppe and Oliveira had been contaminated during casting with a stripping agent—dicetyl phosphate. It has since been found that this contaminated film produces satisfactory fibrosis for hernia repair.

The situation in which a material is to be used has to be considered. A material that has a low resistance to abrasion—for instance some types of moulded nylon, if wet, or polythene (Newman and Scales 1951)—is unsuitable for use in a weight-bearing joint, because abraded particles excite a marked fibrous tissue proliferation with giant cell formation and bone destruction. The same materials used for replacement of bone, but not subject to abrasion, produce scarcely any reaction. This apparently diverse response is the consequence of a physical property of the implant and not the chemical constituents of the material.

The manufacturers of synthetic materials are usually unable to forecast the behaviour of a moulded product subjected within the body to prolonged stress at body heat in the presence of tissue fluids. Under load, thermoplastics are subject to plastic flow and this must always be borne in mind when considering their use for, and the design of, prostheses.

It is essential that systematic investigations are carried out, both *in vitro* and *in vivo*, before a new material is used in man. No material is used in aircraft, for example without thorough laboratory investigation before its incorporation in the structure. The prototype is considered to be an experimental machine and the function of the parts is constantly checked. Specifications are thus developed, and they govern the eventual supply and use of the material. Materials used internally in orthopaedics are not governed in the same manner. Their suitability and the design of the prosthesis is usually established by a process of trial and error in man. Often materials are used before systematic animal experiments have been carried out. It is true that in quadrupeds the stresses and strains upon a joint, for instance the hip, are not the same as in man, but even so considerable information can be gained. Large animals such as goats must be used. The outlay is great, but it is insignificant when compared with the cost of error in the patient.

The experimental work in animals by Venables and Stuck (1947) showed that the "failure of metal appliances in bone surgery was due to electrolytic reactions about the appliance in the presence of blood serum." Their work led to the development of the appliances of stainless steel and non-ferrous alloy which are so widely used at the present time.

Plastic materials are chemically more complex and variable than metals and it is vital that those who investigate them should know the source of supply and the manufacturer's reference. This information should be published so that those wishing to use the material for further work can obtain supplies of constant and known composition.

Two cases of fracture of the stem of the prosthetic replacement are cited by Buxton and Waugh. They state that failure may have been due to a flaw in the metal or to fatigue fracture. Examination of reinforced Judet acrylic femoral heads by means of polarised light will reveal variable stress concentrations in the structure. Polymethyl methacrylate and stainless steel have different coefficients of expansion, and, unless sterilization is carried out carefully, local stress concentrations will possibly result which may later lead to fracture of the prosthesis.

Although surgical instrument makers endeavour to achieve a high standard, there is in fact none to which their product must conform. The whole question of standardisation of materials and design of devices has been admirably dealt with by J. S. Barr in his presidential address to the Nineteenth Annual Meeting of the American Academy of Orthopaedic Surgeons, and his suggestions demand the most careful consideration.

It is tempting to speculate on the future developments of endo-prostheses. Bone, metals and plastics have problems associated with their use which will be solved only by prolonged systematic experiment. It is likely that each will establish itself for certain procedures and that the judicious combination of all three materials will be found useful in the more extensive bone replacements. It seems certain, however, that the replacement of parts of the skeleton is an established orthopaedic practice. Bones can be considered primarily as levers activated by the muscles. Assuming that a material is biologically compatible and mechanically suitable, the problem remaining is the union of living with dead, inert material. Experiments at present unpublished suggest that this can be achieved by making the implant porous, but at the price of mechanical strength. At areas where articulation is required the implant could be made non-porous.

We have the prospect of great and new opportunities for conservative surgery; but only a just appraisal of the hazards and a judicious selection of both patients and materials can prevent many disasters. The task of ultimate assessment must be bequeathed to a future generation.

JOHN T. SCALES.

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LEONARDO DA VINCI AND NICHOLAS ANDRY ON POSTURE

This annotation in the last British number recalled Andry's acknowledgment of Leonardo's observation that a loaded shoulder rises above its fellow. It was not recorded that Andry's words (quoted in the paragraph straddling Figure 2 and in the next sentence) were a paraphrase of Leonardo's own assertion. A translation of this may be found, with a misleading illustration, on page 112 of the English edition of the Treatise on Painting (SENEX, John (1721): A Treatise of Painting by Leonardo da Vinci. Translated from the Original Italian, And adorn'd with a great Number of Cuts. To which is prefix'd, The Author's Life; Done from The Last Edition of the French. London: Printed for J. Senex, at the Globe in Salisbury Court; and W. Taylor, at the Ship in Pater-Noster-Row. MDCCXXI).

H. JACKSON BURROWS.

THE PLACE OF EXTERNAL IRRADIATION IN THE TREATMENT OF OSTEOGENIC SARCOMA

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It is a common belief that in cases of osteogenic sarcoma a chance of cure is afforded only by amputation, and that radiotherapy is useful only for palliation. This is partly true, but not entirely so, for external radiation has a definite place in the curative treatment of certain cases. There is no simple formula which states how these tumours should be dealt with. The decision must rest on the assessment of several factors.

It is especially important that a positive diagnosis be made, otherwise there is no firm ground on which to build. For this reason the cases described here are all drawn from those classified by the Bristol Bone Tumour Registry. A case is classified only as a result of an agreed opinion among the committee of surgeons, orthopaedic surgeons, radiotherapists, diagnostic radiologists and pathologists, a debatable case being left as such. No case is classified without a histological examination of a biopsy, operation or amputation specimen. In this paper a total of thirty-three cases will be considered—eight osteolytic and twenty-five osteoblastic osteogenic sarcomata. No attempt will be made to derive statistical deductions; the numbers are too small. Nevertheless it is considered that detailed qualitative study of a small series may provide useful pointers. Tables I and II show details of each case. The age distribution is shown in Figure 1.

Eight patients have survived for two years or more after treatment—all from the osteoblastic group; and four of these have survived for five years or more. There were no survivors from osteolytic tumours.

Classification and its significance—The subdivision of cases into osteoblastic and osteolytic types is useful in assessing the prognosis. The distinction is based on the radiographic appearances. Histologically about half of the osteolytic tumours in this series were of spindle-cell variety, but only one of the osteoblastic tumours was spindle-celled (Case 31), the rest being polyhedral-celled. There was a high proportion of histological Grade III tumours among the osteolytic cases.

Treatment had little influence on the course of the osteolytic tumours. This was perhaps largely due to the fact that most of the tumours occurred in the axial skeleton, where neither amputation nor effective dosage with radiation was possible. Except for one case in which the patient died soon after admission to hospital, palliative deep x-ray therapy was given in all cases. A dosage of over 5,000r produced good symptomatic relief in some, but in no case of osteolytic tumour was there evidence of real arrest of the tumour growth. Geschickter and Copeland (1949) observed a less unfavourable response to radiation in some of their osteolytic cases. They reported 26 per cent five-year cures in their osteoblastic cases, and 7 per cent in the osteolytic. Our ill-success in this group is partly ascribed to the lack of histological Grade I tumours in the accessible appendicular skeleton. Nevertheless the evidence from our series, so far as it goes, supports the observation of Geschickter and Copeland that the prognosis is worse in the osteolytic type of sarcoma.

Osteolytic sarcomata arise commonly in previously abnormal bone, and in the older patients. These two factors usually go together and, as in the case of osteoblastic tumours, are associated with a poor prognosis.

TABLE I

CLINICAL FEATURES IN EIGHT CASES OF OSTEOLYTIC OSTEOGENIC SARCOMA

Case	Age	Length of history (*months*)	Site	Pain	Swelling	Histological grade	Mitotic ratio	Treatment to primary growth
1	5½	2	Humerus	Slight	+	II	190	DXR 2,000r + 2,000r + 1,200r
2	61	3	Ilium	+	+	II	198	Palliative DXR
3	42	8	Ilium	+	+	Not available	Not available	DXR 5,860r in 2 courses
4	27	2	Orbit	+	+	III	92	DXR 800r
5	71	3	Ilium	+	+	III	91	DXR 3,000r and 2,500r
6	62	2	Skull	+	+	III	65	DXR 3,500r
7	86	0	Femur	—	—	III	91	None
8	13	1	Femur	+	+	III	83	DXR 4,200r and amputation

Length of history before treatment—Differing views on the importance of this may be held. On the one hand, a case with a short history may tend to be an early case, while that with a long history has had more time in which metastases may have developed. This is one viewpoint based on one effect. The other viewpoint is that in a case with a short history the tumour is of more aggressive type and has reached the point of driving the patient to a doctor in a shorter time; and because of its greater activity and malignancy it will metastasise sooner than the slow growing type with a long history. Therefore a short history has a worse prognosis.

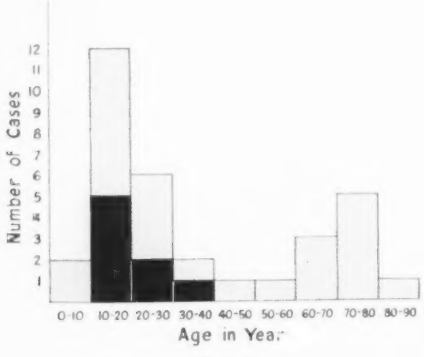

FIG. 1

Figure 1—Age distribution of osteogenic sarcomata and of survivors. The black sections represent survivors.

A study of the cases presented in Table II bears out neither viewpoint. The average length of history among the survivors was 3·7 months. The average length of history in all cases was 3·8 months. The difference was too slight to be significant. Coley and Pool (1940) and Platt (1947) also found that the length of history was without significance. MacDonald and Budd (1943), however, found that the prognosis was better in cases with a long history. Possibly there is some truth in both viewpoints, and the two effects balance. The practical

TABLE I—*continued*

Response	Freedom from recurrence	Result	Pre-existing bone affection	Special features
Slight	—	Death after 6 months		
Slight	—	Death after 8 months		
—	—	Death after 8 months		
Nil	—	Death after 2 months	Fibrous dysplasia	
—	—	Death after 11 months	Paget's disease	
Nil	3 months	Death after 5 months	Paget's disease	
—		Death on day of admission	? Chondroma	Pathological fracture, and death on day of admission
—	10 months	Death after 15 months		

but unfortunate fact appears to be that in too many cases matastasis to the chest has preceded symptoms which drive the patient to the doctor.

Histological features, grading and mitotic ratio—Osteogenic sarcoma is derived from tissues that carry the potential ability to form bone. Chondrosarcoma, though a variant of this group in its broadest sense, has not been included in this series.

It is possible to grade osteogenic sarcomata by histological methods as Grade I, II or III, in what appears to be an ascending order of malignancy. The method is applicable to both

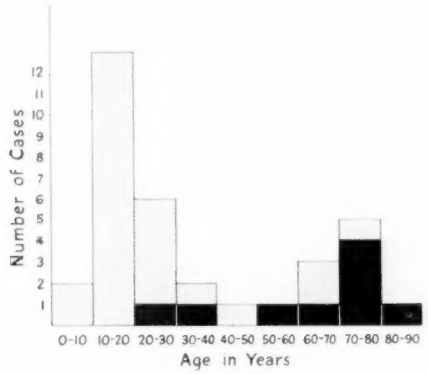

FIG. 2

Figure 2—Age distribution of all cases showing, as black sections, patients with pre-existing bone affections.

polyhedral and spindle-celled types. The amount and type of tumour matrix is not a reliable criterion, and while the degree of cellularity and the morphology of the cells were features of some value, the most important feature was the degree of nuclear activity as estimated by the mitotic ratio (the ratio of the total number of tumour-cell nuclei counted to the number found to be in mitosis). The following ranges were found: Grade I—mitotic ratio greater than 400 to 1; Grade II—mitotic ratio between 400 to 1 and 100 to 1; Grade III—mitotic

TABLE II

CLINICAL FEATURES IN TWENTY-FIVE CASES OF OSTEOBLASTIC OSTEOGENIC SARCOMA

Case	Age	Length of history (*months*)	Site	Pain	Swelling	Histological grade	Mitotic ratio*	Treatment to primary growth
9	18	2	Femur	Severe	Definite	I	433	DXR Amputation
10	13	10	Humerus	Marked	Definite	I	677	DXR 6,700r
11	14	1	Femur			I	773	DXR Amputation
12	21	6	Femur			I	421	DXR Amputation
13	38	3	Femur			II	125	Local resection DXR 3,000r + 3,000r
14	10	10	Humerus			I	727	DXR 8,500r + local resection
15	17	24	Femur			I	888	DXR 1,500r + 1,500r Amputation
16	15	1	Femur			II	125	DXR Amputation
17	15	1	Tibia			II	206	DXR 3,000r + 3,000r + 2,000r
18	58	2	Pelvis			II	180	DXR 4,000r
19	22	14	Humerus			II	195	DXR 4,200r + 1,000r
20	38	12	Tibia			II	236	DXR 3,000r + 3,000r + amputation
21	70	2	Femur	Slight		II	132	DXR 3,200r + 1,500r
22	24	1	Femur			II	113	DXR Amputation
23	9	3	Vertebra			II	153	DXR 1,500r + 500r
24	26	2	Femur		Slight	II	108	DXR Amputation
25	73	3	Femur		Great	II	174	DXR Amputation
26	14	2	Femur	Marked	Marked	II	135	DXR Amputation
27	64	12	Vertebra			II	163	None
28	19	1	Tibia	Severe	Slight	III	43	DXR 3,700r + 2,800r
29	73	6	Mandible	Slight		III	65	DXR 3,000r
30	74	3	Tibia			III	48	DXR 2,700r
31	27	5	Femur			III	73	DXR 8,000r + amputation
32	13	1	Femur			III	88	DXR Amputation
33	15	2	Humerus			III	57	DXR Amputation

TABLE II—*continued*

Response	Freedom from recurrence	Result	Pre-existing bone affection	Special features
+ +	10 years	Alive and well		
+ +	5 years	Alive and well		At first taken for inflammatory condition
+ +	6 years	Alive and well		
+ +	5 years	Alive and well		Resembled inflammatory condition at first
+ +	20 months	Alive and well	Cyst	
+ +	2 years	Alive and well		Resembled inflammatory condition at first
+ +	5 years	Death after 6 years		Suggestive of infective condition at first
+ +	2 years	Alive and well		
+	6 months	Death after 18 months		
Slight	—	Death after 6 months	Paget's disease	
+	—	Death after 14 months		
+	9 months	Death after 3 years		Lung metastases present for 18 months
Slight	—	Death after 7 months		
+ +	2½ years	Death after 6 years		
Nil	—	Death after 1 month		
+	10 months	Death after 13 months		
Slight	1 month	Death after 1 month	Paget's disease	
Definite	4 months	Death after 5 months		
—	—	Death after 1 month		
+ +	8 months	Death after 10 months		
+	—	Death after 3 months	Osteitis fibrosa	
Slight	—	Death after 3 months	Paget's disease	
+ +	13 months	3 years survival but metastases present		Local recurrence and amputation at 13 months. Lung metastases at 3 years
+	3 months	Death after 4 months		
+	4 months	Death after 6 months		

ratio less than 100 to 1. In Grade I cases a long survival period was the rule, and the five-year survival group was nearly coincident with the Grade I cases.

Age of patient and influence of pre-existing bone affections—The average age of the survivors was just under nineteen years. The average age of non-survivors was thirty-eight years. This demonstrates that the younger age group carried the better prognosis (Fig. 1). In fact, all of the eleven patients over the age of forty died. There were only two patients under ten, and both died. These findings are similar to those of Coley and Pool (1940). In patients over forty there was usually some suggestion of a pre-existing bone condition, such as Paget's disease, fibrous dysplasia, cyst or chondroma (Fig. 2). Of the nine patients with one of these conditions, only one has survived for more than one year after treatment. Osteolytic tumours were more often associated with these conditions than were osteoblastic tumours. Thus a pre-existing bone affection was present in five out of twenty-five osteoblastic cases, and four out of eight osteolytic cases. The British Empire Cancer Campaign report of 1949 mentioned the high incidence of Paget's disease in osteogenic sarcoma in patients over fifty years of age, and estimated that 8 per cent of patients with Paget's disease develop osteogenic sarcoma.

Significance of an atypical clinical history—In four cases (Cases 10, 12, 14 and 15) the local signs were at first suggestive of an inflammatory lesion. Three of these patients are now survivors, apparently free from disease, and one is dead after surviving for six years. These cases form a small atypical group with a better prognosis. Three of them are among the cases to be described in detail.

Radiographic appearances—Here again there is no clear-cut criterion by which to classify the cases. On the whole, the group with better prognosis shows a predominance of bone reaction over destruction, and the cortex is expanded or thickened rather than destroyed. Subperiosteal new bone formation is present, perhaps markedly so, but evidence of erosion of this new bone is absent or slight, and late in appearance, while sun-ray spicules are not marked. Codman's " triangle " is absent in these cases, and this is perhaps the only clear sign.

This leads to the position that in the group of atypical cases of better prognosis, where a distinction between an inflammatory lesion on the one hand and a malignant tumour on the other is most needed, those radiographic features that tend to define the case as malignant are absent.

Osteolytic sarcomata tend to arise centrally, showing a central area of destruction which involves the cortex without expanding it, and produces some periosteal reaction. Geschickter and Copeland (1949) record that leucocytosis and fever may occur, and that such tumours are easily confused with infection or other bone tumours, such as Ewing's tumour. Fever was not a noticeable feature, however, in our cases.

Discussion—From the foregoing it may be seen that there is a group of osteogenic sarcomata in which the prognosis is better than average. But it is not a clear-cut group. It may be indicated by an atypical clinical history, in which at first the symptoms and appearances favour an inflammatory lesion of the bone. Or it may be indicated by an indefinite radiographic picture, which again resembles that of an inflammatory condition or other benign change within the bone. This group of atypical osteogenic sarcomata may possibly turn out to be separable from the others as a distinct variety, just as primary reticulosarcoma of bone has been separated from Ewing's tumour (Coley 1949) or classified as an atypical Ewing's tumour by Geschickter and Copeland (1949). There is, however, no pathological evidence of such a distinction so far.

A more definite indication of this relatively favourable group of sarcomata is given by pathological grading after biopsy. A fairly reliable and precise grading is given by the mitotic ratio already referred to. Of the six patients with Grade I tumours in the series, five are survivors with no recurrence, four of them for five years or more. The sixth patient died after six years, having been apparently free from recurrence for five years. This last case

brings out the fact that some tumours recur more than five years after the primary has been dealt with. The fact that two deaths in this series occurred after six years bears out the suggestion of Coley and Harrold (1950) that a five-year survival rate does not give a complete picture of cures obtained. A longer interval, perhaps seven to ten years, may be needed for this. However, according to Coley and Harrold, a patient surviving five years has a twelve to one chance of cure.

Atypical clinical or radiographic findings and pathological grading tend to be coincident in the same patient. Nevertheless it is not possible to explain the atypical cases as examples of mistaken diagnosis, due to the occasional difficulty of histological interpretation, because some of them later produce metastases of sarcoma confirmed at post-mortem (see Case 15). For the same reason, the cases of atypical tumours that have been cured by x-rays alone cannot be explained as inflammatory. Case 10 represents a five-year cure from x-ray treatment, and in Case 14 there were no identifiable tumour cells on detailed histological examination of the bone removed by local resection two years after x-ray treatment. It should be noted, however, that cure by radiation entails a high dose with its risk of bone necrosis, so that a local resection of the bone is recommended at a suggested interval of six months after radiation. The two cases mentioned are described in detail below to illustrate this, and the indications for this form of treatment are discussed later.

Cases that do badly whatever the treatment adopted are the following: 1) cases of Grade III histology (mitotic ratio less than 100); 2) cases of Grade II histology with pre-existing bone pathology; 3) cases in the older age group (over forty or fifty); 4) tumours of the axial skeleton where adequate treatment is impossible and the diagnosis may be late; and 5) most osteolytic tumours.

Note should be taken of the fact demonstrated by Price (1952), that the mitotic ratio of biopsy material from benign bone conditions ranges from 1,500 to 5,000. No tumour even of Grade I has fallen within this range. This distinction that histological examination can give between benign and malignant lesions, together with the guide to prognosis and treatment that it affords, makes biopsy necessary and justified in every case of osteogenic sarcoma.

It should be emphasised that in most cases of this series in which treatment was by x-ray therapy alone, the dosage was suitable for growth restraint rather than attempted cure, and was often given in repeated courses.

ILLUSTRATIVE CASE REPORTS

Case 14—Schoolgirl aged ten. Had had pain in the right shoulder for seven months when she was first seen by a surgeon. The condition was ascribed to osteomyelitis and the first biopsy specimen was reported as showing chronic inflammation; radiographs were reported as typical of osteomyelitis. Later radiographs, however, showed an area of bone destruction surrounded by bone reaction, and much subperiosteal bone formation which was destroyed in part, but possibly only by surgical intervention (Fig. 3). These films were still not considered diagnostic, but as the symptoms persisted a second biopsy was performed ten months after the onset of pain. The sections showed definite evidence of osteogenic sarcoma, and the case is accepted as such by the registry.

Treatment—Owing to the site of the tumour and previous intervention, amputation was not performed. X-ray therapy was given, a dose of 8,000r being delivered in thirteen weeks.

Progress—There was a dry desquamative reaction of the skin; radiographs one year after treatment showed consolidation of the periosteal reaction and increase of bone sclerosis (Fig. 4). There was no evidence of metastases in the chest. All pain had gone within two months of treatment and movements were full, though some thickening of the bone was still palpable. The condition remained unchanged until six months after the cessation of treatment, when pain recurred, though the radiographic appearances were unchanged. Local resection of the affected bone was carried out.

Examination of the specimen showed necrosis of the bone which was sufficient to account for the pain. No sarcoma cells were identified in the bone, but only a few degenerate cells which might have been the remains of them. The patient is well and there are no signs of metastases.

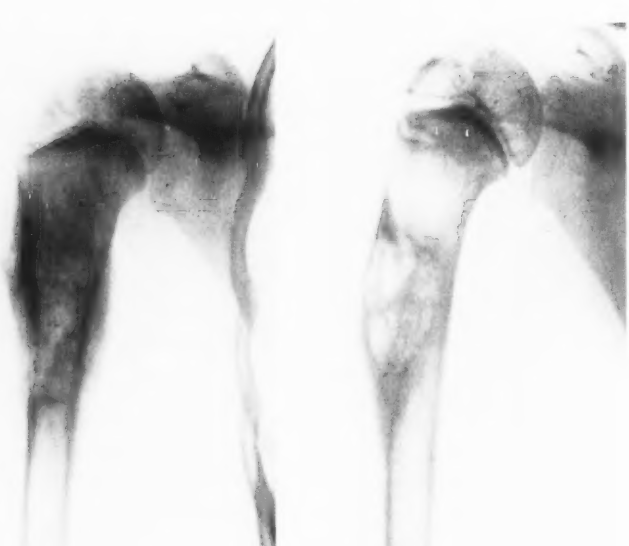

FIG. 3 FIG. 4

Case 14. Figure 3—After biopsy and before treatment. Figure 4—One year after treatment.

Comment—This case is described to support the view put forward elsewhere in this paper, that in the absence of distant metastases the treatment of osteogenic sarcoma of the upper limb should be deep x-radiation to the limit of skin tolerance, over a long period if possible, followed after all reaction has subsided by a local resection. In this case the programme of treatment was not decided beforehand, so that too long an interval elapsed between radiation and resection. The interval should not be prolonged until either late necrosis of bone or recurrence from a few remaining viable sarcoma cells occurs. Secondly, this case illustrates the type in which the radiographic and physical signs do not show a well defined picture of osteogenic sarcoma, but, at least at first, are suggestive of osteomyelitis. It seems that in such cases the course of the disease is slower and the prognosis better. Accordingly, conservative treatment by radiation and local resection appears well justified.

Case 10—Boy aged twelve years at onset of symptoms. Complained of pain in the right elbow, followed a few days later by swelling. When he was seen (at Colombo) seven months after the onset of pain radiographs suggested a tuberculous lesion, though sarcoma could not be excluded. Biopsy was performed but the sections were reported as showing no evidence of malignancy or osteomyelitis; the appearances suggested localised osteitis fibrosa. Two months later, when he was first seen in Bristol, the elbow was very swollen and painful. A further biopsy was done and the sections were reported by the Bristol University Department of Pathology as showing osteogenic sarcoma of a slowly growing type. The Bone Tumour Registry classified the tumour as osteoblastic osteogenic sarcoma. The radiographic appearances are shown in Figure 5.

Treatment—Deep x-ray treatment was undertaken. A dose of over 7,000r was given over a period of twelve weeks.

Progress—Dry desquamation of the skin occurred. After two months the pain had disappeared and the swelling had receded so much that the olecranon could again be felt. At no time was there evidence of metastases. The radiographic appearance seven months after treatment is shown in Figure 6. Eighteen months after treatment moderate movement of the elbow was possible. But delayed effects of radiation on the bone appeared, and radiographs two years after treatment showed a pathological fracture of the ulna (Fig. 7).

FIG. 5

Case 10. Immediately before X-ray treatment.

FIG. 6

FIG. 7

Case 10. Figure 6—Six months after treatment. Figure 7—Two years after treatment, showing pathological fracture.

Five years after treatment there was no evidence of recurrence, though there was much fibrosis of the area. The latest report, five and a half years after treatment, indicates that he is well, the arm is useful and the fracture has healed.

Comment—This case is reported to demonstrate that a "five-year cure" of some osteogenic sarcomata is possible by radiation alone. As in Case 14, the dose successful in subduing the tumour produced necrosis of bone. For this reason, as well as to reduce the likelihood of recurrence, local resection of the affected bone after radiation is advisable, if practicable.

Case 11—Girl aged fourteen years at onset of symptoms. Complained of pain in her left knee. A lump soon appeared, and the appearances were typical of sarcoma of femur both clinically and radiographically. Pre-operative deep x-ray therapy was given (4,300r in two months) and the leg was amputated four months later. The patient was well and free from recurrence six and a half years after amputation. The mitotic ratio of the tumour was 733 to 1.

Case 9—Boy aged eighteen at onset. Complained of pain in his left leg for ten weeks before examination. Clinical and radiographic appearances were typical of osteogenic sarcoma of the femur. Biopsy was performed and the diagnosis confirmed. Pre-operative radiation was given over a period of three days and amputation was done immediately afterwards. The patient has remained well with no signs of recurrence. He was last seen nine years after treatment. The mitotic ratio of the tumour specimen was 433 to 1.

Comment—The performance of biopsy in this case did not prevent long survival.

Case 12—Patient aged twenty-one years. Osteogenic sarcoma of femur. The limb was amputated immediately after a pre-operative dose of deep x-ray therapy. Five years later he is well and free from metastases.

Comment—This case is interesting again in that the early signs favoured inflammation, and the first biopsy was indefinite. Of the four five- to ten-year "cures" of osteogenic sarcoma in the series, two were atypical in this way at first.

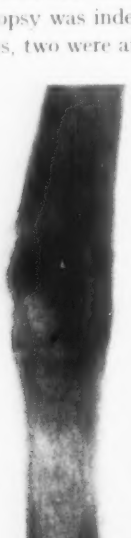

FIG. 8

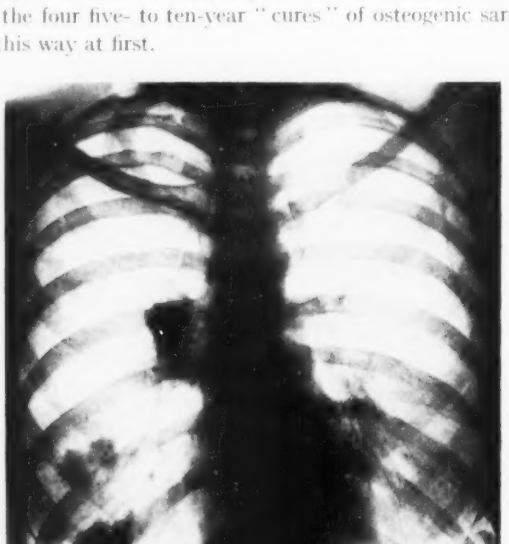

FIG. 9

Case 15. Figure 8—The primary tumour. The features of this case were at first atypical of sarcoma in several respects, but the patient's death from pulmonary metastases confirmed the diagnosis of tumour. Figure 9—Bony metastases in chest five years after amputation.

Case 15—Girl aged seventeen at onset of symptoms. She had had a pain in the mid-third of the left thigh for two years, and a local swelling at that site for most of the time. Radiographs had been taken at intervals but no positive diagnosis of tumour had been reached (Fig. 8). Biopsy

was performed, and the stony hard swelling broke the drill. The sections were reported as showing osteogenic sarcoma. Amputation was carried out two years after the first symptoms.

Progress—The patient remained well for five years, when she complained of pain in the chest. Radiographs revealed multiple calcified metastases in the chest (Fig. 9). These were similar in appearance to the soft tissue calcification round the primary. She died a year later.

Comment—This is an unusual case. The total history extended over eight years, for five of which, after amputation, there was no evidence of tumour, and at one point it could have been called a "five-year cure." The mitotic ratio was low—888 to 1.

The radiograph illustrated (Fig. 8), taken six months before amputation, is quite atypical. There is no clear sign of reactive bone being in turn destroyed by tumour, and so no Codman's "triangle." The appearance could well be accepted, as it was for two years, as of infective origin. The site of the lesion in the mid-shaft site is also atypical of osteogenic sarcoma, as is the long history.

The features of this case have been described because it illustrates a type of seemingly low malignancy. Two other such cases (Cases 10 and 14) are described in detail here. Those cases have so far been treated successfully, but in spite of the definite histology, and because of indefinite radiographic appearances, some may believe that they were really infective lesions and not tumours. In this case lung metastases eventually appeared, and here at least the atypical condition was proved indisputably to be a tumour.

Biopsy was not obtained in this case until other features pointed strongly to the diagnosis, and at a late stage. The histological diagnosis was not then in dispute. In some such atypical cases that come to investigation earlier (for example, Cases 12 and 14), the first biopsy shows only granulation tissue or an appearance of chronic infection. If a second biopsy later shows evidence of sarcoma, the earlier indefinite report should not be allowed to discourage acceptance of the second. These atypical cases appear slow to develop clear diagnostic evidence pathologically, as well as radiologically and clinically.

TREATMENT

The foregoing discussion and the illustrative case reports provide evidence upon which to base suggestions for the treatment of these tumours. It is suggested that deep x-ray therapy is not merely of use as a palliative agent but may have a principal part to play in radical treatment. There are of course definite limitations. Paterson (1948) underlines this. He classes osteogenic sarcoma among the radio-resistant tumours, the dose required to destroy the tumour being frequently high enough to destroy normal tissues. Coley (1949) records that 4,000r to 6,000r have a good temporary effect, but 6,000r to 9,000r were needed for more permanent results.

Hitherto, x-ray therapy has mainly been used either shortly before amputation, or as palliative treatment when amputation is contra-indicated. The cases in the present series are too few to allow us to assess the usefulness of pre-amputation radiotherapy. Higinbotham and Coley (1942), analysing a much larger American series, reported a 3 per cent improvement in survival rate after pre-amputation radiation. This slight improvement is not significant in itself, but is perhaps of the order of magnitude to be expected. Trauma to the tumour and limb, from manipulations during preparation for operation and during the early stages of operation itself, though not great, is present in some degree. The purpose of pre-amputation radiation is to render the tumour more quiescent and make dissemination less likely during the time between the patient's first attendance and the completion of amputation. Cade (1947) favoured pre-amputation radiation. It is suggested here also that whenever amputation is to be performed as curative treatment, pre-operative radiation should be given. Technique varies according to individual preference. The dosage may be at the rate of 3,000 to 4,000r in three to five weeks, or, if preferred, a smaller dose may be given rapidly, amputation being performed immediately after the last treatment.

X-ray therapy alone—Evidence from this series suggests that cure may be obtained in some cases by heavy x-ray treatment alone. As already mentioned, this carries a risk of necrosis, and in two of the cases reported necrosis occurred in the treated bone. The suggestion is therefore made that in otherwise suitable cases local resection of the bone should be undertaken after full x-ray dosage, after reaction to radiation has subsided at, say, four or six months interval. Resection should help to prevent local recurrence from the diseased bone in the more resistant cases. The dosage may be of the order of 8,000r in ten weeks, or otherwise 800r per week to tolerance. With present equipment, this routine can be adequately applied only to limb bones.

The cure rate from amputations is at present bad, primarily because lung metastases are already present in most cases. The conservative routine may well be able to provide as good a cure rate as amputation in suitable cases, because even when the tumour is not destroyed, in most cases it becomes quiescent during the course of x-ray treatment and remains so for a considerable period afterwards, as indicated by the cessation of pain and of growth of the tumour. Sclerosis of the bone increases, and the tumour more nearly acquires the character of a Grade I case, if it is not of this grade already. Under these circumstances local resection may be carried out with little risk of causing metastases at operation, and metastases during the interval between the commencement of radiation and operation becomes improbable. Local resection of the bone during the period of quiescence removes the site of possible local recurrence.

It is urged that this plan of treatment, when surgically practicable, should be given extended trial over a number of years. It is especially suitable for tumours of the upper limb, where preservation of the hand is so valuable. It will be inadvisable for tumours of the lower limb if in the opinion of a surgeon local resection will not leave a stable leg, and an artificial leg would be better. In that event pre-operative irradiation and amputation should be preferred. Radical x-ray treatment and local resection are especially to be encouraged if the first response to radiation is good, if the case shows the atypical history or radiographic signs discussed above, if there is Grade I histology and a low mitotic count, and if the patient is young. The treatment is contra-indicated if the patient is old or if there are metastases elsewhere, and it is discouraged if there is pre-existing bone disease, Grade III pathology, or an osteolytic tumour. In resistant cases, in which the tumour does not respond to the course of radiation, amputation must be performed. If the serum alkaline phosphatase is raised at the outset, it should fall if there is good response to radiation, when 4,000r or over have been given (Coley 1949). A rise at a subsequent date may indicate recurrence.

The form of deep x-ray treatment recommended here is dependent on the technique commonly available now. It is of course recognised that super-voltage therapy, the assistance of biochemical factors, or even a rearrangement of time-dosage relations may alter the picture at any time. It is also recognised that to effect a major improvement in the results obtained from the therapy of tumours in histological Grades II and III, an effective treatment must be found for pulmonary metastases. Cade has already reported good local response to super-voltage therapy.

SUMMARY AND CONCLUSIONS

The foregoing suggestions may be summarised in the following recommendations for the treatment of osteogenic sarcoma.

1. Deep x-ray therapy in high dosage, followed by local resection, should be given serious trial especially: 1) in the upper limb; 2) in the group with atypical clinical or radiographic signs, or histology resembling that of inflammatory lesions; 3) with Grade I histology; and 4) in the young.

2. Deep x-ray therapy followed at once by amputation should be used for osteogenic sarcoma if: 1) local resection would leave a lower limb more unstable than an artificial leg; or 2) if response to x-rays is poor.

3. Deep x-ray therapy alone should be used: 1) if the patient is unsuitable for, or refuses, any operation; and 2) palliatively, if metastases are present or the tumour is too advanced, or the patient is not fit for radical treatment.

4. Amputation alone should be used palliatively, for pain or fungation, when x-ray therapy has failed to relieve, or is not readily obtainable.

5. Biopsy and histological grading must be performed in every case. A histological diagnosis is most important. Coley (1949) and MacDonald and Budd (1943) support this view.

6. The records of every possible case should be sent to and discussed by a group with special experience of these tumours.

I am greatly indebted to Dr C. H. G. Price, secretary to the Bristol Bone Tumour Registry, for his help with the histological aspects of this work; and to the British Empire Cancer Campaign, whose support has made the activities of the Registry possible.

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ACUTE OSTEOMYELITIS OF THE MAXILLA IN INFANCY

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Acute osteomyelitis of the maxilla in infants is an uncommon but distinct clinical entity. Its onset, clinical course, and bacteriology are so constant that no surgeon who is aware of the clinical picture should fail to diagnose the condition at an early stage.

Less than one hundred cases have been reported in the English and American literature since the condition was first described by Rees in 1847, and reference has been found to only thirteen cases since the introduction of penicillin. Asherson (1939), in a comprehensive review, stated that he saw only four cases during ten years work at two London hospitals. Lacy and Engel (1939) reported one case and summarised thirty-six cases reported between 1922 and 1939. Table I summarises the cases reported since 1928.

Before the introduction of chemotherapy, the mortality in this condition was estimated at between 25 and 30 per cent. In the last thirteen cases recorded since 1945, there has been only one death. The disease, however, varies in severity, and fulminating cases occur in which only the early administration of the correct antibiotic is likely to save the life of the infant. In many cases a prompt diagnosis and efficient chemotherapy would in all probability cut short the course of the disease and avoid the disfiguring complications which have attended so many of the cases in the past. Penicillin-resistant strains of the staphylococcus aureus are becoming increasingly common to-day, and in the light of our present knowledge it appears that aureomycin is the antibiotic of choice when the resistance of the organism to penicillin has been established in the laboratory.

CLINICAL FEATURES

The disease is essentially an acute inflammation of the maxilla with a spreading thrombosis of its nutrient vessels, followed ultimately by sequestration of necrotic bone and tooth follicles. In mild cases, or when the acute phase has been cut short by early chemotherapy, the inflammatory process may subside without sequestration, but in the past such a clinical course has been exceptional. In severe cases the disease may rapidly become septicaemic, leading to death within a few days. Most cases pursue a relatively chronic course, characterised by a short acute stage lasting a few days, which is followed by a stage of prolonged purulent discharge and sequestrum formation.

The primary stage—The disease occurs in infants at any time from shortly after birth up to twelve weeks of age. The onset may be preceded by skin infection in the child or mother, but many cases have been reported in which no definite etiology has been established. The first sign is the appearance of swelling and redness below the inner canthus of the eye in the lacrimal region with, a short time later, oedema of the eyelids on the affected side. There is a sharp pyrexia, with severe malaise, and it is at this stage that a mistaken diagnosis of acute dacryocystitis or orbital cellulitis may be made. The early diffuse swelling and inflammation of the cheek are characteristic of acute osteomyelitis; they are not observed in orbital cellulitis, and are seen only as a late sign in infection of the lacrimal sac.

The next sign is swelling of the alveolar margin in the region of the canine fossa and first deciduous molar tooth, followed within a day or so by a sinus discharging pus, which yields a pure growth of staphylococcus upon culture. Simultaneously, or even before this stage, a sinus forms below the inner canthus and, if a probe is passed upwards from the

TABLE I

REVIEW OF CASES REPORTED IN THE LITERATURE SINCE 1928

Author	Cases	Age	Predisposing factors	Organism	Treatment	Duration	Result	Complications
Bass (1928)	2	3 weeks	Impetigo	Staphylococcus aureus	Drainage	6 months	Recovery	Faulty dentition.
		10 weeks	—	Staphylococcus aureus	Drainage	1 month	Recovery	Unknown
Goldbloom and Bacal (1937)	1	3 weeks	—	Staphylococcus aureus	Drainage	3 months	Recovery	Deformity from sequestration of most of maxilla and malar
Lacy and Engel (1939)	1	1 week	Boils	Not known	Drainage	3 months	Recovery	Scar deformity
Asherson (1939)	4	10 weeks	Coryza	Not known	Drainage "Prontosil"	3 months	Recovery	Unknown
		2 weeks	—	Staphylococcus aureus	Drainage	5 days	Death	Broncho-pneumonia
		12 weeks	—	Staphylococcus aureus	Drainage Sulphonamide	7 months	Recovery	Unknown
		10 weeks	—	Staphylococcus aureus	Drainage Sulphonamide	6 weeks	Recovery	Marked toxaemia
Jacoby and Sagorin (1945)	2	3 weeks	2 weeks premature	Staphylococcus aureus	Penicillin	11 days	Recovery	None
		6 weeks		Staphylococcus aureus	Penicillin	10 days	Recovery	None
Dunphy and Fraser (1947)	1	9 days		Staphylococcus aureus	Penicillin Sulphathiazole	4 weeks	Recovery	None
Haworth (1947)	5	4 weeks	—	Staphylococcus aureus	Penicillin Drainage Sulphadiazine	6 weeks	Recovery	Unknown
		4 weeks	—	Staphylococcus aureus	Penicillin Drainage	2 weeks	Recovery	Unknown
		7 weeks	Septic finger	Staphylococcus aureus	Penicillin Drainage	4 weeks	Recovery	Unknown
		12 weeks	—	Staphylococcus aureus	Penicillin Drainage Sulphadiazine	18 days	Recovery	Unknown
		15 weeks	Coryza	Not known	Penicillin Drainage Sulphadiazine	30 days	Death	Gastro-enteritis, mastoiditis, otitis media
Howard and Robinson (1948)	1	2 weeks		Staphylococcus aureus	Penicillin	15 days	Recovery	Unknown
Cohen (1949)	1	3 weeks	After circumcision	Staphylococcus aureus	Penicillin	1 month	Recovery	Unknown
Macbeth (1951)	1	6 weeks		Staphylococcus aureus	Penicillin Drainage	Not known	Recovery	Stenosis of lacrimal duct
McCash and Rowe (1952)	2	4 weeks	5 weeks premature. Fed by nasal tube	Staphylococcus aureus	Drainage Streptomycin	3 months	Recovery	Minimal scar. Late effects not yet known
		4 weeks	Mother had acute mastitis	Staphylococcus aureus	Drainage Streptomycin Chloromycetin Aureomycin	3 months	Recovery	Minimal scar. Late effects not yet known

opening within the mouth, a communication may be established between the two sinuses. Finally, a unilateral nasal discharge begins upon the affected side, and in all probability indicates a spread of the infection to involve the antrum.

The swelling of the orbit commonly gives rise to exophthalmos accompanied by ophthalmoplegia and chemosis of the eyelids, but the globe of the eye itself is unaffected. In the mouth the swelling extends halfway across the palate, and other sinuses frequently appear along the alveolar margin, from which pus may be obtained by gentle pressure in the buccal sulcus or palate.

Radiological investigation is of no value in the primary phase, for the osteoporosis induced by the pathological process takes about three weeks to develop. The diagnosis must rest upon the characteristic clinical picture, the age of the patient, the consistent sequence of events and the constant nature of the organisms cultured from the pus.

The secondary stage—When free drainage has been established by natural or surgical means the temperature usually settles within a few days and the disease enters upon a prolonged chronic phase. This is characterised by a discharge from multiple sinuses within the mouth or below the inner or outer canthus of the eye. There is no marked evidence of toxaemia except during recurrent exacerbations which occur when free drainage is not maintained.

The secondary stage persists until sequestra or devitalised tooth buds are extruded naturally or removed surgically. The final sequestrum is commonly separated from below the outer canthus, and appears to consist of the outer third or two-thirds of the inferior orbital margin. The average duration of this stage is two to three months. The chronic suppuration may lead to adherent scars beneath the lower eyelid, and there may be permanent deformity from asymmetry of the maxilla and loss of teeth, which may require subsequent correction by plastic or dental surgery.

DIFFERENTIAL DIAGNOSIS

The condition is most commonly diagnosed as orbital cellulitis or dacryocystitis, but may occasionally be confused with ophthalmia neonatorum. The principal diagnostic features are set out in Table II.

SURGICAL ANATOMY

In the newborn infant the antrum is a rudimentary structure which occupies only a small part of the maxilla, whereas in the adult it occupies the greater part of the bone (Figs. 1 and 2). In the adult the orbital floor is thus separated from the tooth-bearing alveolus by the full depth of the antrum, but in the infant the orbital floor and the alveolar process are adjacent and almost continuous, the intervening area being filled with the crypts of the calcified but as yet unerupted deciduous teeth, and the developing tooth germs of certain of the permanent teeth. The antrum in the infant measures 10 millimetres antero-posteriorly, 6 millimetres in height and 4 millimetres in greatest width (Asherson 1939). It lies almost vertically above the crypt of the first deciduous molar tooth, which at that stage is larger than the cavity of the antrum, and forms a disproportionately prominent bulge in the alveolar margin. It will be appreciated, therefore, that infection developing in or around the crypt of the first deciduous molar tooth may rapidly involve both the antrum and the orbit, since both of these structures lie in close proximity to the tooth crypt and to each other.

PATHOLOGICAL FEATURES

Bacteriology—In the overwhelming majority of cases the staphylococcus aureus has been the causative organism. In some instances failure to secure adequate drainage has resulted in the culture of one of the common mouth contaminants—chiefly coliform organisms or diphtheroids—to which the infection has been incorrectly ascribed.

FIG. 1

Skull of newly born infant showing the anatomy of the maxillary region. (By courtesy of Mr N. Asherson).

FIG. 2

Antero-posterior radiograph of the skull of a newly born infant, showing the small maxillary antrum. The left antrum shows up clearly as a circular cavity and is indicated by the arrow. (By courtesy of Mr N. Asherson.)

TABLE II

DIFFERENTIAL DIAGNOSIS

	Osteomyelitis of the maxilla in the neonatal period	Orbital cellulitis	Acute dacryocystitis	Ophthalmia neonatorum
Age	Almost invariably within the first twelve weeks of life	Unusual before six months of age, but any age thereafter	At any age	Signs present about the third day in most cases
Organisms	Staphylococcus pyogenes aureus	Streptococcus	Streptococcus	Gonococcus; pneumococcus; staphylococcus
Orbital signs	Unilateral swelling of the upper and lower eyelids with proptosis, chemosis and ophthalmoplegia. The centre of the swelling is situated on the floor of the orbit at the inner or more rarely on the outer aspect	Unilateral swelling of upper and lower eyelids with proptosis, chemosis and ophthalmoplegia. The swelling is on the medial aspect near the floor of the orbit except in adults where it is nearer the roof	Unilateral swelling of the lower eyelid, which is initially confined to the vicinity of the lacrimal sac	Bilateral swelling of upper and lower eyelids, with purulent conjunctivitis and corneal ulceration in the later stages if untreated
Nasal signs	Unilateral nasal discharge on the affected side, appearing as a later sign; staphylococci can be cultured from the pus	Bilateral nasal discharge from which streptococci can be cultured	Simple catarrhal inflammation usually present, from which a mixed flora may be cultivated	—
Facial signs	Signs of inflammation are present over the canine fossa and cheek on the affected side. Later, the inflammation may spread to temporal fossa	—	The inflammatory process begins in the region of the lacrimal duct and sac, and spreads to involve the cheek later	—
Oral signs	Swelling and tenderness of the alveolus, buccal sulcus, canine fossa and palate on the affected side. Later, sinus formation and extrusion of tooth follicles and sequestra occur	—	—	—
Response to treatment	In early cases, with the correct chemotherapy, the condition may be aborted. Otherwise a chronic condition ensues with fistula formation and discharging sinuses. Removal of sequestra is essential	Response to chemotherapy and drainage is good; subsequent relapse and breakdown is uncommon	Response to chemotherapy in the acute stage is good. Chronic fibrosis in and around the sac may necessitate a subsequent dacryocystorhinostomy	Response to chemotherapy is good

Etiology—Many theories have been advanced concerning the route of infection and the exciting cause. Some writers consider that the infection is haematogenous, and spreads from an infection of the umbilical cord or from skin abrasions. Bass (1928) and Lacy and Engel (1939) have described cases in which a skin infection existed before the development of the osteomyelitis. Earlier writers ascribed the condition to an empyema of the antrum of Highmore, with later spread to the maxilla. But if this were so it would be expected that the nasal infection and discharge would precede the general signs, whereas in fact they appear after the inflammatory changes in the cheek and the formation of sinuses in the alveolus.

The involvement of the first deciduous molar tooth is a consistent feature, and the consensus of present opinion is that this tooth, or more precisely the region of the tooth follicle, is the central point from which infection spreads in the maxilla. The tooth is formed from a downgrowth of the dental lamina or anlage about the sixth week of intra-uterine life, and begins to calcify at the twenty-fourth week of intra-uterine life. As already mentioned, the crypt of the tooth forms a prominent bulge in the alveolar ridge of the maxilla of the newborn infant and lies in close proximity to the floor of the antrum, which it exceeds in size. A tract of epithelial cells persisting from the original anlage leads down to the crypt, and is known as the gubernaculum because the breakdown of these cells is thought by some authorities to assist in the eruption of the tooth. It is reasonable to suppose that the prominence occupied by this tooth is liable to trauma or abrasion from the manipulations of a mucous catheter, or from the finger nails of the nurse or mother during routine cleansing of the mouth after feeds. The introduction of a virulent pathogenic organism—derived perhaps from infected cracked nipples or from unsterilised feeding utensils—into such an abrasion might well be the exciting cause of the infection.

Pathology—In the *acute stage* the marked inflammatory reaction causes a hyperaemia of the surrounding vessels, which are unable to dilate within the confines of the bone. A spreading infective thrombosis of the vessels occurs, and a progressively larger area is involved as the perivascular inflammation extends throughout the maxilla. The infection spreads to the cheek, where a diffuse cellulitis occurs, and to the antral floor. Suppuration occurs within twenty-four to forty-eight hours, and the pus breaks through the outer plate of the maxilla, taking the line of least resistance through the antero-medial and superior aspect of the tooth follicle. Pus collects close to the lacrimal gland but does not involve its structure, and a discharge occurs into the nose from the antrum, which by now has developed an empyema. The floor of the orbit is involved, and subperiosteal infection leads to oedema of the periorbital tissues. The infection may spread around the lateral aspect of the maxilla and pass distally to involve the pterygoid plexus, the infra-temporal fossa and later the temporal fossa, where a localised abscess may form. In the mouth, neighbouring tooth follicles usually become involved, and discharging sinuses form in the alveolus.

In the *chronic stage* necrotic bone and devitalised tooth follicles constitute a chronic focus of irritation around which a low-grade infection persists. These sequestra are eventually extruded or exfoliated, the last one often being the outer third of the inferior orbital margin. It is probable that the richer anastomosis in the region of the inner canthus protects the bone in this region from destruction. Cavernous sinus thrombosis and meningitis are rare complications, but a close watch must be kept for them.

CASE REPORTS

Case 1—Infant boy delivered five weeks prematurely by caesarean section after pregnancy complicated by toxaemia. Fed by nasal tube. Twenty-six days after birth, an area of redness was observed over the region of the left lacrimal sac, with swelling of the eyelids on the same side. Dacryocystitis was suspected and instillation of penicillin, with "sulphatriad" 0·25 gramme given four-hourly by mouth, was begun. Four days later the swelling was larger and the infant was admitted to hospital. The temperature in the groin was 100 degrees Fahrenheit and the child was obviously ill. *On examination*, it was found that thick pus was escaping from the upper buccal sulcus on the left side. Culture revealed only non-haemolytic staphylococcus albus. Radiographs showed some blurring of the maxillary margins. *Treatment*—Penicillin (100,000 units twice daily) and "sulphatriad" (0·125 gramme four-hourly by mouth) were given and the mouth was swabbed with gentian violet after each feed. *Operation* was undertaken the next day; an incision was made over the left lacrimal sac; pus escaped under tension. The left maxillary antrum was washed out, but appeared to be clear of infection. The first upper deciduous molar tooth on the left side was removed. After the operation the temperature returned to normal; both sinuses discharged freely.

The child was transferred to the Plastic and Oral Surgery Unit, Rooksdown House, on the eleventh day of the infection. At that time he was five weeks old. There was pyrexia of 100·2

degrees Fahrenheit. The weight was seven pounds and the general condition was poor. *On examination* there was diffuse swelling and redness of the left cheek, with proptosis, chemosis, and ophthalmoplegia of the left eye (Fig. 3). There was a fluctuant swelling over the left temporal fossa. The incision below the inner canthus from the first operation had closed but there was a profuse mucopurulent discharge from the left nostril. Within the mouth, there was oedema of the left buccal sulcus, with a sinus in the region of the first deciduous molar tooth from which pus could be freely expressed. There was slight swelling of the palate on the left side. A further operation to secure efficient drainage was considered necessary. *Operation*—An incision was made in the left buccal sulcus, and pus under considerable tension escaped. Sinus forceps passed easily upwards beneath the zygomatic arch to the temporal region. Two tube drains were inserted for irrigation. Culture of the pus revealed staphylococcus aureus in pure culture. The organism was not sensitive to penicillin but sensitive to streptomycin.

After operation the cavity was irrigated every two hours with normal saline followed by penicillin solution (2,000 units per millilitre). Penicillin (200,000 units twice daily) was given by

FIG. 3

FIG. 4

Case 1. Figure 3—Eleven days after onset. Figure 4—Appearance six months later.

injection pending the laboratory report on the sensitivity of the organism. Satisfactory improvement occurred in the clinical condition. Blood examination two weeks after the onset showed haemoglobin 64 per cent (8·96 grammes per cent), red blood corpuscles 2,520,000 per cubic millimetre, and leucocytes 12,000 per cubic millimetre.

Progress—Five days after the second operation the washouts were clear and the drains were removed. But two days later there was a recurrence of infection in the cheek, and a leucocyte count of 24,000 per cubic millimetre. A further operation was undertaken. The sinuses in the mouth and buccal sulcus were reopened and a drain inserted. A transfusion of 50 millilitres of whole blood was given. In view of the insensitivity of the organisms to " sulphatriad " and penicillin, a course of streptomycin (0·75 gramme twice daily) was begun.

Two days after this third operation a further abscess developed below the outer canthus of the left eye. An incision was made below the outer canthus, and a drain inserted. Six weeks later (nine weeks after the onset of the infection) two sequestra were extruded from the sinus in the cheek. The larger piece appeared to be part of the outer third of the inferior orbital margin. The sinuses now soon closed and remained completely healed. The general condition returned to normal and at discharge from hospital eleven weeks after the onset the weight was

twelve pounds. When seen six months later the infant was in good health. Apart from a slightly depressed scar at the outer orbital margin there was no deformity (Fig. 4).

Case 2—Infant girl born at full term after normal pregnancy. Birth weight 6 lb. 11 oz. The infant was breast-fed for one week, but this was discontinued owing to the development of an acute breast abscess. Bottle feeding was then begun with half-cream national dried milk.

Three weeks after birth a swelling of the cheek on the right side was observed. Penicillin (300,000 units once daily) was given for three days. During this period a right periorbital swelling developed, and towards the latter part of the period a unilateral nasal discharge began upon the affected side. Orbital cellulitis was suspected, and the child was admitted to a general hospital. At that time the general condition was poor; there was pyrexia of 104 degrees Fahrenheit. There was cellulitis of the lower lid and the soft tissues immediately infero-lateral to the outer canthus. Over the temporal fossa there was an indurated swelling one centimetre in diameter. No direct orbital involvement was apparent. Examination of the mouth revealed a small discharging sinus in the upper right alveolus. The leucocyte count was 17,200 per cubic millimetre (polymorphs 56 per

FIG. 5

FIG. 6

Case 2. Figure 5—Two months after onset, in stage of chronic infection. Figure 6—Appearance three months later.

cent, lymphocytes 25 per cent). Bacteriological examination of the pus revealed coliform organisms resistant to penicillin, but sensitive to sulphonamides, streptomycin and chloromycetin. Streptomycin and chloromycetin were given, but with little clinical improvement. One week after the onset the swelling was fluctuant and operation to secure drainage was undertaken. An incision was made in the right alveolar margin, and gentle pressure on the right lower lid resulted in a free flow of pus. Culture revealed staphylococcus aureus and coliform organisms, both sensitive to chloromycetin. After operation the cellulitis of the lower lid subsided and the temperature returned to normal.

Two weeks after the onset of the disease there was a sudden recurrence of the periorbital infection with an associated pyrexia; the drainage of the intra-oral wound appeared to have ceased. The original incision was re-explored with sinus forceps and drainage again established. As the organisms were sensitive to aureomycin, a course of this antibiotic was begun. Attempts were made to aspirate the pus from the orbital region through the incision in the mouth. A week later a stab incision was made at the outer angle of the lower right eyelid, and a small rubber drain inserted. The periorbital cellulitis subsided, leaving a small circumscribed swelling beneath the lateral half of the right lower lid, which discharged profusely. There was also a constant

discharge of pus from the nose on the same side, and from the sinus in the alveolus. After another two weeks a further incision was necessary beneath the lower right lid to maintain drainage. Three weeks later the child was transferred to Rooksdown House.

Condition on admission—At that time the child was three months old and the infection had been present for two months. The general condition was good, he was taking feeds satisfactorily and gaining weight. Temperature 99·5 degrees Fahrenheit. The sinus below the outer canthus of the right eye was still discharging pus. There was oedema of the lids, but no marked proptosis or chemosis (Fig. 5). Profuse purulent nasal discharge was present. Examination of the mouth showed three sinuses on the alveolus of the maxilla, from which pus could be expressed. A probe inserted into the sinuses detected bare bone, which did not appear to be separated from the maxilla. *Investigations*—Radiographs suggested that there was erosion of the maxilla on the right side, but the appearances were not conclusive. *Bacteriological* culture from the nasal discharge gave staphylococcus aureus, penicillin-resistant.

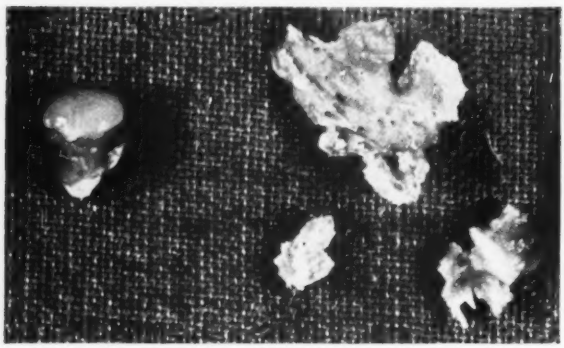

FIG. 7

Case 2—Sequestra and first deciduous upper molar tooth removed at operation ten weeks after the onset of the disease.

Treatment and progress—In view of the chronic nature of the condition it was decided to await clinical evidence of separation of the sequestra before undertaking operation, and to withhold further chemotherapy until the time of operation. For three weeks the general condition remained satisfactory, the temperature fluctuating between 98 and 99·5 degrees Fahrenheit. After this time the sequestra appeared ready for removal. The blood picture at this stage showed: haemoglobin 80 per cent, red blood cells 4,000,000 per cubic millimetre, and leucocytes 11,600 per cubic millimetre. *Operation* was undertaken under aureomycin cover. An incision was made in the buccal sulcus on the right side and the alveolar margin gently explored. Two sequestra and the crown of the first deciduous molar tooth were removed (Fig. 7). The cavity was found to communicate with the sinus below the right lower eyelid; a tube was inserted through this sinus, emerging through the incision in the buccal sulcus.

After operation the tube was irrigated with normal saline every four hours, and removed after forty-eight hours. The temperature rapidly settled, and the wounds healed. Two months later there had been no relapse and the child was in good health: weight 15 lb. The only defect was a slight adhesion of the overlying tissues to the inferior orbital margin (Fig. 6).

DISCUSSION

Both cases presented the typical features of osteomyelitis of the maxilla in infants, and in both an incorrect diagnosis was originally made—in one case dacryocystitis, and in the other orbital cellulitis. Chemotherapy in the early stage was inadequate, and was instituted too late in the disease to have been able to prevent necrosis and subsequent sequestrum formation. The bacteriological picture was confused owing to a failure to cultivate the organisms contained in the true pus, as a result of which staphylococcus albus was initially cultivated in the first case from the skin, and coliform organisms from the oral cavity in the second case. Only after expression of the underlying pus, and its subsequent cultivation, was the characteristic pure growth of staphylococcus aureus obtained.

In each case persistent discharge continued until the necrotic bone separated, and recurrent exacerbations occurred as a result of incisions being allowed to close and consequent inadequate drainage. After removal of the sequestra there was rapid healing. In both cases the first deciduous molar tooth was involved; it was removed early in the first case and at the time of sequestrectomy in the second.

In assessing the significance of blood examination in young infants it is important to recall the normal blood picture at birth, and during the first three months of life. Average figures are shown in Table III.

A leucocytosis is normal in infancy and more reliance must be placed upon a relative polymorphonuclear leucocytosis replacing the normal relative lymphocytosis of infancy in assessment of the response to acute infection. This is illustrated by the findings in Case 2, in which a total white count of 17,200 per cubic millimetre included 56 per cent of polymorphonuclear leucocytes and only 25 per cent of lymphocytes, a reversal of the normal ratio in infancy. Moreover the physiological anaemia of infancy must be borne in mind when assessing the haemoglobin readings. Within a period of twelve weeks the haemoglobin drops from 140 per cent at birth to 70 per cent at three months of age, but after the first month the red cell count should remain at 5,000,000 per cubic millimetre, so that variations in this figure are possibly of greater value in assessing the haemolysis resulting from toxic infection.

TABLE III

AVERAGE COMPOSITION OF THE BLOOD IN YOUNG INFANTS

	At birth	One month	Three months
Haemoglobin (per cent)	140	100	70
Red blood corpuscles (per cubic millimetre)	7,000,000	5,000,000	5,000,000
Leucocytes (per cubic millimetre)	18,000	15,000	15,000

The authors consider that the present high incidence of penicillin-resistant staphylococcal infections merits the immediate exhibition of aureomycin in an attempt to prevent bone necrosis, and to cut short the disease. Though of bitter taste, aureomycin can be given without difficulty dissolved in a few drachms of the infant's feed. The dose is 25 milligrams per kilogram body weight.

SUMMARY

1. The literature on acute osteomyelitis of the maxilla in infants is reviewed and the improvement in the prognosis since the introduction of chemotherapy is noted.

2. The clinical features, diagnosis, surgical anatomy, pathology, and bacteriology are discussed and the constant pathogenicity of the staphylococcus aureus stressed. It is suggested that the first deciduous molar tooth is the centre of the early bone infection, and that the infection begins in the mucosa overlying this tooth.

3. Two cases are reported. Both were caused by a penicillin-resistant staphylococcus aureus.

4. The early use of aureomycin in an attempt to abort the infection is advocated.

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FRACTURES OF THE CALCANEUM

With an Atlas Illustrating the Various Types of Fracture

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Divergence of opinion still exists about the merits of the various methods of treatment of fractures of the calcaneum. We consider that a necessary preliminary to the application of any form of treatment is an accurate description of the course of the main lines of fracture and the displacement of the principal fragments. With this in view we have classified a large series of recent fractures of the calcaneum and studied particularly the mechanism of the compression-shearing injuries and the fracture patterns which these usually produce.

RADIOGRAPHIC EXAMINATION

As we have said elsewhere (Bremner and Warrick 1951) we subject cases of suspected fracture of the calcaneum to radiography in the lateral and axial projections and in Anthonsen's oblique projection. The technique employed for taking the axial projection is that in which the Potter-Bucky diaphragm is used (Fig. 1). The resulting radiograph should demonstrate clearly the subtalar joint and with care such a radiograph can be produced without undue discomfort to the patient in almost every case of recent fracture of the calcaneum. In Anthonsen's (1943) oblique view the bone is projected as shown in Figure 2. The dorsiflexed foot is placed in the lateral position on the film and the ray is directed to a point just below the medial malleolus with an angulation of 25 degrees towards the foot of the table (cranio-distally) and 30 degrees towards the toes (dorsi-ventrally). The ray strikes the posterior articular facet tangentially and passes in the direction of the long axis of the sulcus calcanei (Fig. 3).

MECHANISM OF FRACTURE

Three hundred fractures of the calcaneum have been classified, as shown in Table I, into two main groups. Much remains to be learned concerning the mechanism of fracture of Group I. It is proposed here, however, to confine discussion to the mechanism of those fractures which constitute Group II.

The compressional force and shearing strain to which the calcaneum is subjected when the heel strikes the ground as a result of a fall from a height are much greater than the forces of normal weight bearing. If the impact is sufficient to fracture the bone the fracture will run forwards and laterally from a point on the medial side a variable distance behind the sustentaculum tali. We call this the *primary fracture* and it may extend in three ways: It may traverse the posterior articular facet; it may enter the sulcus calcanei medial to the facet and then pass towards the lateral side of the bone; or it may reach the lateral side of the bone by passing behind the posterior articular facet. The primary fracture thus divides the bone into two main fragments. The main lateral fragment lies postero-lateral and the main medial fragment antero-medial to the primary fracture.

If the primary fracture is unassociated with a secondary compression fracture (described below) of the main lateral fragment the following variations of fracture may be recognised. 1) Fracture of the posterior articular facet without displacement (Fig. 19). 2) Fracture of the posterior articular facet with lateral displacement of the main lateral fragment (Figs. 21 and 22). 3) Fracture with diminution of the salient angle but without involvement of the

posterior articular facet—the "retrothalamic" fracture of Continental writers. Here the primary fracture passes behind the posterior articular facet (Figs. 23 and 24).

The above fractures do not constitute the majority of compression fractures, because the continued action of the forces which produce the primary fracture will drive the main lateral fragment and that part of the articular surface which it bears against the under surface of the talus, and a *secondary compression fracture* of the main lateral fragment may be produced.

FIG. 1

Position for radiography of calcaneum in axial projection using Potter-Bucky diaphragm.

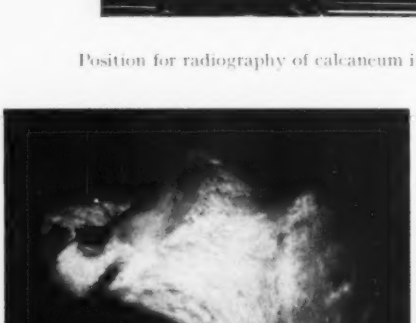

FIG. 2

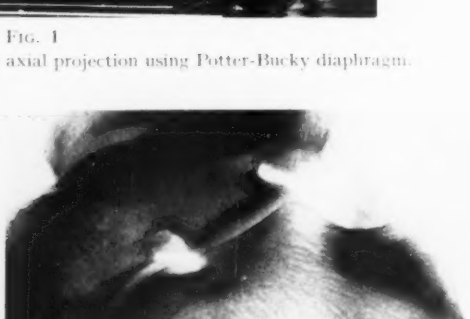

FIG. 3

Figure 2—Photograph of the calcaneum as it lies in Anthonsen's projection. Observe that the ray strikes the posterior articular facet tangentially and passes along the long axis of the sulcus calcanei. Figure 3—Radiograph of normal calcaneum in Anthonsen's projection. (Reproduced from the Journal of the Faculty of Radiologists.)

This results in depression and rotation of that part of the articular surface which lies lateral to the primary fracture. Depending upon whether the primary fracture runs across the posterior articular facet or enters the sulcus calcanei one of the following fractures is produced. 1) Fracture with depression of the lateral part of the posterior articular facet. 2) Fracture with depression of the entire posterior articular facet.

Further study of the last two fractures—those in which there is a secondary compression

fracture of the main lateral fragment—shows that each is met with in two types (Palmer 1948). In the first (Type 1), the part of the articular facet which lies lateral to the primary fracture (this includes the entire facet when the fracture enters the sulcus calcanei) is depressed into the underlying bone (Figs. 25 to 27 and Figs. 31 to 33). In the second type (Type 2) the depressed articular surface is continuous with the upper part of the main lateral fragment, which is split horizontally (Figs. 28 to 30 and Figs. 36 to 38). The lateral wall of the bone is frequently comminuted in these fractures and this comminution may run forwards to involve the lateral part of the calcaneo-cuboid joint.

DISCUSSION

Watson-Jones (1943) has pointed out that fractures of the calcaneum include as many varieties of injury as fractures of the knee or fractures of the ankle. For the detailed

TABLE I

ANALYSIS OF 300 FRACTURES OF THE CALCANEUM TREATED AT THE ROYAL VICTORIA INFIRMARY 1947–1952

Group I		
Isolated fracture of the anterior end of the bone		40
Isolated fracture of the sustentaculum tali		1
Fractures of the tuberosity		35
"beak" fracture	4	
vertical fracture	31	
Group II. Compression-shearing fractures.		
With diversion of the bone into two main fragments only		86
Involving but not displacing the posterior articular facet	28	
Involving the posterior articular facet and accompanied by lateral displacement of the main lateral fragment	9	
With diminution of the tuber-joint angle but no involvement of the posterior articular facet	49	
With diversion of the bone into two main fragments and secondary compression fracture of the main lateral fragment		138
Fracture with displacement of the lateral part of the posterior articular facet		
Type 1	63	
Type 2	34	
Total	97	
Fracture with displacement of the entire posterior articular facet		
Type 1	23	
Type 2	18	
Total	41	

description of most of the fractures of this bone we consider that a study of the appearances in all three radiographic projections is usually required.

In addition to differentiating between fractures that are associated with articular injury from those that are not, it is important also to recognise the two sub-groups (Types 1 and 2) of the injuries that involve the posterior articular facet. The incidence of the Type 2 injury is less than that of Type 1 (Table I), but in the treatment of these Type 2 cases restitution

of the depressed articular surface by traction on the upper fragment of the horizontally split tuberosity may be successful. In the Type I cases traction on the tuberosity cannot elevate the depressed articular surface. In either variety it may be considered justifiable to elevate the displaced facet at open operation and to maintain it in place by inserting a bone graft beneath it.

The observations in this paper have been made during the course of an investigation into fractures of the calcaneum which has been assisted by a grant from the Stephen Scott Research Fund of the Medical School, King's College, University of Durham. We are indebted to Dr S. Whately Davidson and Mr C. Gordon Irwin for permission to carry out this work in their departments.

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AN ATLAS ILLUSTRATING FRACTURES OF THE CALCANEUM

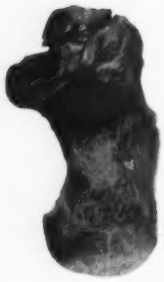

FIG. 4

FIG. 5

FIG. 6

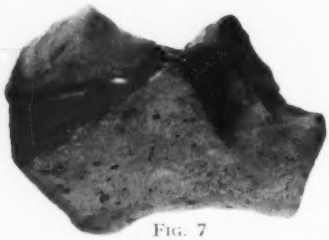

FIG. 7

Figure 4—Fracture of the anterior end of the bone involving the calcaneo-cuboid joint.

Figure 5—Vertical fracture of the tuberosity.

Figure 6—Isolated fracture of the sustenaculum tali.

Figure 7—" Beak " fracture of the tuberosity.

FIG. 8

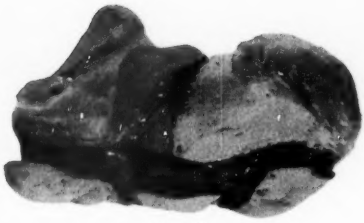

FIG. 9

FIG. 10

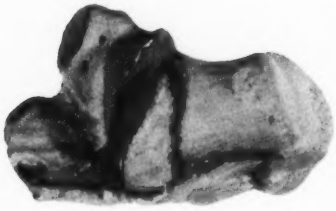

FIG. 11

FIG. 12

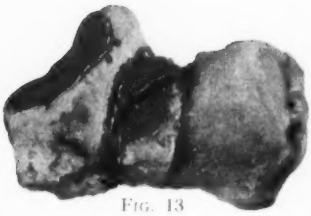

FIG. 13

FIG. 14

Figure 8—Fracture involving but not displacing the posterior articular facet.

Figure 9—Fracture with diminution of the tuber-joint angle but no involvement of the posterior articular facet.

Figure 10—Fracture involving the posterior articular facet with lateral displacement of the main lateral fragment.

Figure 11—Fracture with depression of the lateral part of the articular surface (Type 1).

Figure 12—Fracture with depression of the lateral part of the articular surface (Type 2).

Figure 13—Fracture with depression of the entire posterior articular surface (Type 1).

Figure 14—Fracture with depression of the entire posterior articular surface (Type 2).

FIG. 15

FIG. 16

Figure 15—Isolated fracture of the anterior end of the calcaneum (see Fig. 4). The fracture involves the anterior talo-calcaneal and calcaneo-cuboid joint surfaces. Figure 16—Vertical fracture of the tuberosity (see Fig. 5).

FIG. 17

FIG. 18

Figure 17—Isolated fracture of the sustentaculum tali (see Fig. 6). The fracture isolates the sustentaculum tali from the rest of the bone. This fracture must not be confused with that in which the primary fracture enters the sulcus calcanei and there is depression of the entire posterior articular surface as illustrated in Figures 36 to 38. Figure 18—The so-called "beak" fracture of the tuberosity (see Fig. 7).

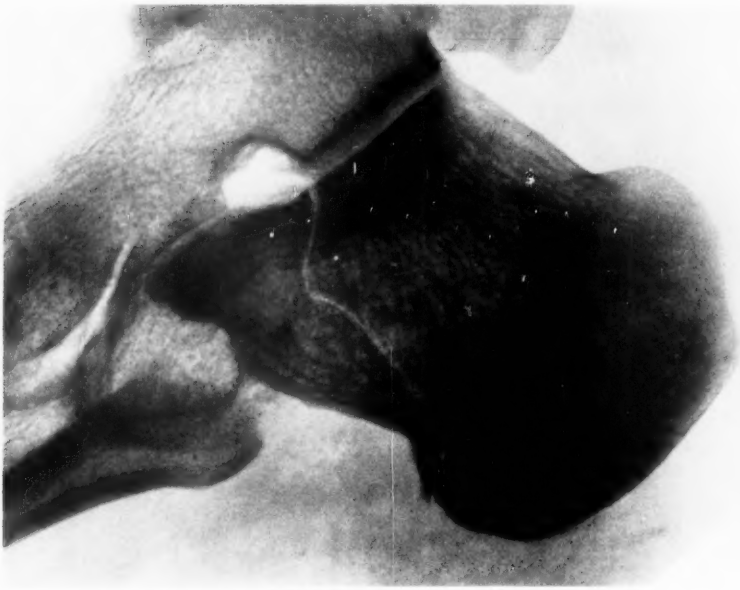

FIG. 19

FIG. 20

Fracture dividing the calcaneum into two main fragments. Two examples of this fracture are shown by radiographs taken in Anthonsen's oblique projection and in the lateral projection respectively. In neither is there any significant displacement to be seen nor is there any compression of the main lateral fragment. In Figure 19 the fracture enters the sulcus calcanei and the entire posterior articular facet is situated on the main lateral fragment. In Figure 20 the fracture runs from the medial to the lateral side behind the posterior articular facet. The model illustrated in Figure 8 shows the fracture crossing the articular surface.

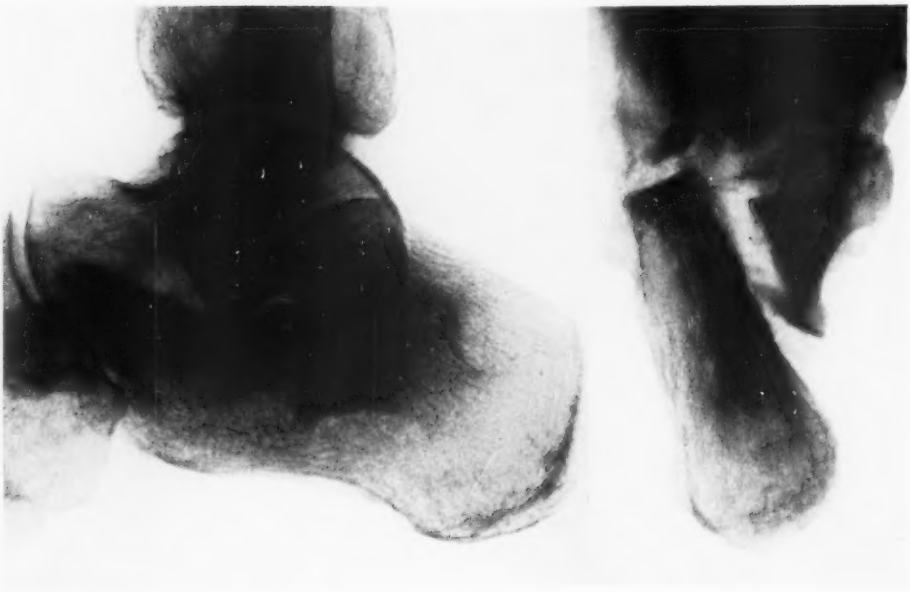

FIG. 21 FIG. 22

Fracture involving the posterior articular facet with lateral displacement of the main lateral fragment (see Fig. 10). In this variety there is no secondary compression fracture of the main lateral fragment.

FIG. 23 FIG. 24

Fracture with diminution of the tuber-joint angle but no articular injury (see Fig. 9). Here the primary fracture passes behind the posterior articular facet. There is no secondary compression fracture of the main lateral fragment since this is not compressed against the talus.

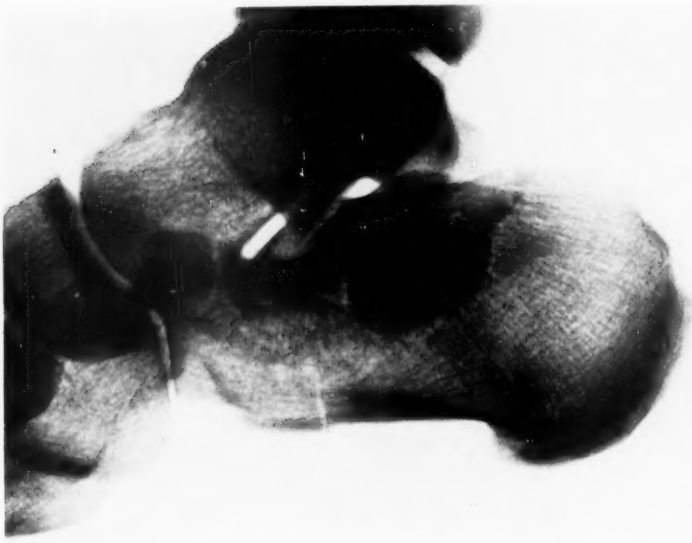

FIG. 25

FIG. 26

FIG. 27

Fracture with depression of the lateral part of the posterior articular facet. Two types of this fracture are met with. In the Type I, illustrated by these radiographs taken in the lateral, Anthonsen's oblique, and axial projections, and in the model shown in Figure 11, it will be seen that the lateral part of the articular surface is driven into the underlying bone.

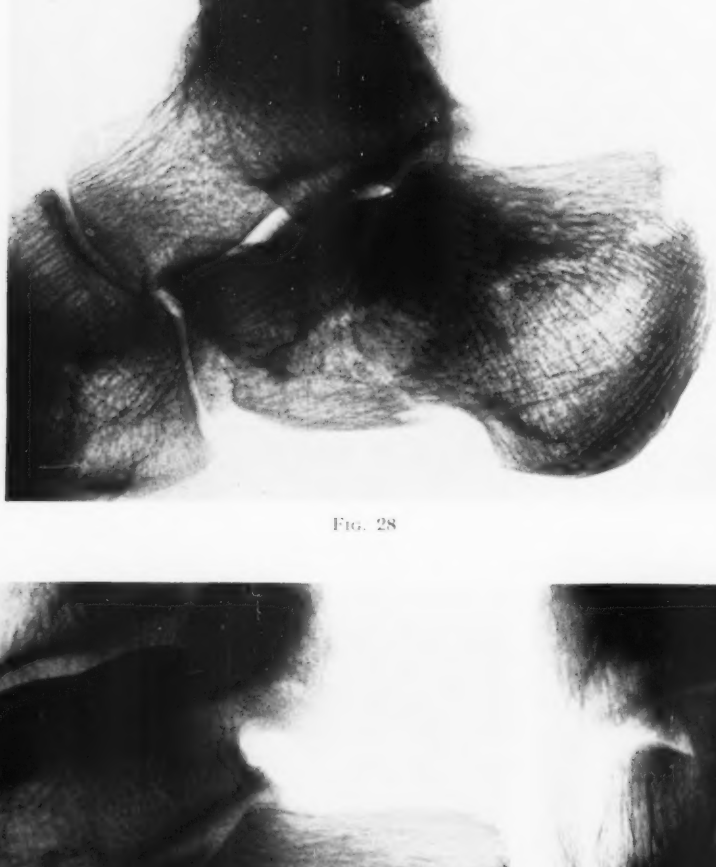

FIG. 28

FIG. 29

FIG. 30

Fracture with depression of the lateral part of the posterior articular facet. These radiographs and the model shown in Figure 12 illustrate the Type 2 variety of this fracture. It will be seen that the lateral part of the joint surface is depressed in continuity with the upper part of the horizontally split main lateral fragment.

FIG. 31

FIG. 32

FIG. 33

Fracture with depression of the entire posterior articular facet. This fracture is also met with in two types. In Type 1, illustrated here and in Figure 13, the primary fracture is usually complex, radiating from its point of origin on the medial wall of the bone and sending a branch into the sulcus calcanei and another across the facet. The articular surface is depressed into the underlying bone and is usually comminuted.

FIG. 34

FIG. 35

Fracture with depression of the entire facet (Type 1) may also occur with no comminution of the depressed articular surface. This unusual fracture is illustrated by these radiographs taken in the lateral and in Anthonsen's oblique projections.

FIG. 36

FIG. 37

FIG. 38

Fracture with depression of the entire posterior articular facet. Type 2. This fracture is also illustrated in Figure 14. The primary fracture will be seen to enter the sulcus calcanei and horizontal splitting of the main lateral fragment is evident. The entire articular surface is depressed in continuity with the upper part of the split tuberosity.

ELMSLIE'S OPERATION FOR THE CALCANEUS FOOT

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Elmslie's method of midtarsal-subtalar [subastragaloid] arthrodesis and tendon transplantation for paralytic talipes calcaneo-cavus is not well known and it is believed that the operation is of sufficient value to justify a description.

During the past fifty years numerous operations have been used in the treatment of this condition. In 1901 Whitman introduced excision of the talus [astragalectomy], by which he was able to displace the foot backwards and form a single hinge joint between the tibia and fibula and the anterior part of the calcaneum [os calcis], the cuboid and the navicular [scaphoid]. Robert Jones (1908) devised a two-stage operation of midtarsal-subtalar and ankle arthrodesis. Midtarsal wedge resection was followed two weeks later by a wedge resection of the subtalar joint and fusion of the ankle joint. He modified this operation when some power remained in the calf by shortening the posterior capsule and the tendo calcaneus [achillis] instead of fusing the ankle joint. Naughton Dunn (1918) improved upon this method by performing a one-stage midtarsal and subtalar resection combined with transplantation of the posterior tibial and peroneal tendons into the calcaneum or tendo calcaneus. The control provided by the tendon transplant overcame the necessity to fuse the ankle joint. This operation may be more easily performed in two stages—triple arthrodesis followed some weeks later by tendon transplantation; and, in the later years of life, Dunn usually preferred to do it thus. The operation was a notable advance and is still one of the more commonly used and successful procedures in the treatment of calcaneo-cavus deformity. Hoke (1921) described a technical modification of triple arthrodesis in which the head and neck of the talus were removed, modelled and replaced to obtain suitable correction of the foot. Lambrinudi (1933), while describing his ingenious and effective operation for drop foot, mentioned that a technique employing similar principles might be used for talipes calcaneus. Correction of the calcaneus deformity was obtained by removal of a wedge from the upper surface of the calcaneum and this correction was maintained by removing and reversing the head and neck of the talus.

Elmslie described his operation (Figs. 1 and 2) in the second edition of Carson's *Operative Surgery* (1934), and it is impossible to do better than quote his words. "A combined operation of arthrodesis, tendon transplantation and tendon fixation is used for the treatment of talipes calcaneus. At the first stage Steindler's stripping of the under surface of the os calcis is carried out to flatten the arch and an arthrodesis of the astragalo-scaphoid joint is performed at the same time. The foot is then fixed in plaster of Paris in strong dorsiflexion for a period of six weeks. At a second operation a vertical incision four or five inches long is made along the inner border of the tendo achillis. The tendons of flexor longus hallucis, flexor longus digitorum, peroneus longus and brevis are isolated and divided as low down as possible. Posterior subastragaloid arthrodesis is then carried out. A strip of the tendo achillis is fixed to the back of the tibia holding the foot in about 20 degrees plantar flexion and the four tendons mentioned are transplanted into the tendo achillis just above its insertion. The foot is fixed in plaster of Paris in 20 degrees plantar flexion and the plaster kept on for a total period of three months."

In paralytic talipes calcaneus the essential weakness is that of the posterior calf muscles, and the greatest deformity occurs when the peronei and the long flexors remain strong. Dunn (1919) wrote that, in poliomyelitis, if paralysis of all the muscles controlling the foot is complete, there is usually little deformity; the deformity is most marked when some

muscles remain active, and this is always the cause in calcaneo-cavus deformities. He explained that the deformity of calcaneo-cavus appeared to be due not so much to the paralysis of the tendo calcaneus but to the effort of the other posterior tibial muscles to assume its function and to the unopposed action of its antagonistic muscles. For an operation to be successful in the correction and maintenance of the correction of the deformity of paralytic talipes calcaneus it is essential to obtain stability by an arthrodesis and a physiologically balanced foot. In Elmslie's operation the two-stage arthrodesis corrects the bony element of the deformity and stabilises the foot. Muscle balance is obtained by the transplantation of the deforming muscles, the posterior tibials and the peronei, into the weak or paralysed muscles, the calf (Fig. 2.). This strengthens the muscle whose weakness is the prime cause of the deformity and at the same time removes the deforming factor which will increase or reproduce the deformity. Elmslie's operation has also the advantage that it can be modified to suit individual conditions and needs. Thus both the talo-navicular and calcaneo-cuboid joints can be arthrodesed without materially altering the operation. Similarly in the second stage it may not be necessary or desirable in some cases to transplant all the posterior tibial and peroneal muscles or to use a strip of the tendo calcaneus to form a tenodesis.

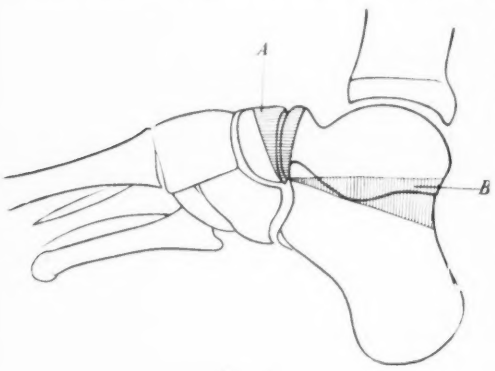

FIG. 1

Elmslie's operation. Diagram showing wedges of bone removed: *A* at first stage, *B* at second stage.

Dunn (1919) said that no agreement had yet been reached by orthopaedic surgeons on the treatment of talipes calcaneo-cavus. Although over thirty years have passed since this statement was made it is probably as true to-day, and the number of different operations for the correction of this deformity exemplifies this. Elmslie's operation was a real contribution to the treatment of this difficult condition; it should be recognised as such and given a place in orthopaedic text-books.

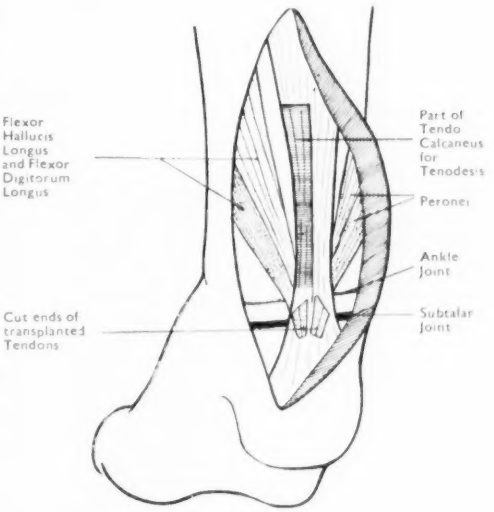

FIG. 2

Elmslie's operation. Diagram showing transplanted tendons.

ILLUSTRATIVE CASES

Case 1—Girl, born 1932; developed poliomyelitis 1939. Elmslie's operation 1943. Pre-operative calf power 0.* Muscles transplanted into tendo calcaneus were flexor digitorum longus (power 3), peroneus longus (power 4) and peroneus brevis (power 4). After operation the power of the calf was 4. When seen two years later there was no recurrence of the deformity (Figs. 3 and 4).

Case 2—Girl, born 1931; developed poliomyelitis 1936. Elmslie's operation 1943. Pre-operative calf power 0. Muscles transplanted into tendo calcaneus were tibialis posterior (power 3+),

* Medical Research Council grading.

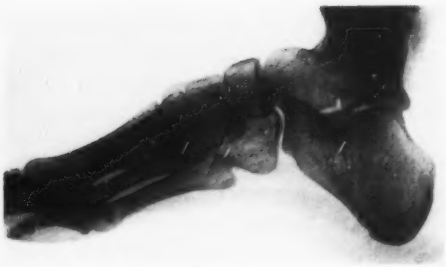

FIG. 3

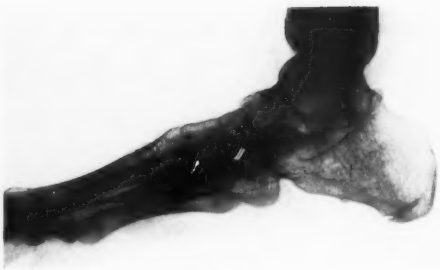

FIG. 4

Case 1. Figure 3—Before operation. Figure 4—Nine months after correction of calcaneo-cavus deformity by Elmslie's operation.

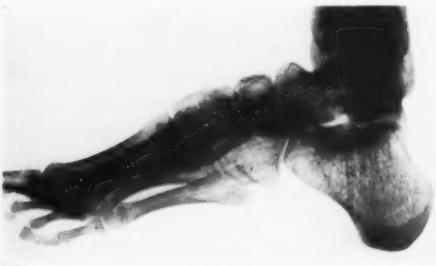

FIG. 5

FIG. 6

Case 2. Figure 5—Before operation. Figure 6—One year after correction of calcaneo-cavus deformity by Elmslie's operation.

FIG. 7

FIG. 8

Case 4. Figure 7—Before operation. Figure 8—Eight months after Elmslie's operation.

peroneus longus (power 4) and peroneus brevis (power 4). After operation the power of the calf was 4. There was no recurrence of deformity five years later (Figs. 5 and 6).

Case 3—Boy, born 1932; developed poliomyelitis 1938. Elmslie's operation 1944. Pre-operative calf power 1. Muscles transplanted into tendo calcaneus were flexor hallucis longus (power 4), peroneus longus (power 4) and peroneus brevis (power 4). After operation the power of the calf was 4. Six years later there was no recurrence of deformity.

Case 4—Boy, born 1939; developed poliomyelitis 1941. Elmslie's operation 1948. Pre-operative calf power 0. Muscles transplanted into tendo calcaneus were tibialis posterior (power 4), peroneus longus (power 4) and peroneus brevis (power 4). After operation the power of the calf was 4. Three years later there was no recurrence of deformity (Figs. 7 and 8).

Case 5—Girl, born 1937; developed poliomyelitis 1942. Elmslie's operation, with removal of navicular, in 1949. Pre-operative calf power 0. Muscles transplanted into tendo calcaneus were flexor digitorum longus (power 4), flexor hallucis longus (power 4) and peroneus brevis (power 4). Post-operative calf power was 3½. Two years later there was no recurrence of deformity.

SUMMARY

1. Paralytic talipes calcaneus and calcaneo-cavus are difficult deformities to correct and keep corrected. Many operations have been devised for this purpose.

2. Emslie's operation is a simple procedure by which satisfactory correction can be obtained and maintained. It can be modified to suit individual cases without altering the basic principles of the procedure and is physiologically sound.

3. Illustrative cases are described.

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RECURRENT DISLOCATION OF THE ELBOW

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A recent dislocation of the elbow is sometimes very unstable; recurrence must be prevented by splinting, and control radiographic examinations are required every few days until this danger has passed. But there appear to be only a few reports of the rare disability of recurrent or habitual dislocation of the elbow in the last eighty years since Albert described the first example in 1881 (Sommer 1928). The surprising feature of these few cases is the variety of attributable causes and the number of operations designed to remedy this disorder — twelve, including modifications, in the seventeen cases mentioned in this paper. The causes include fracture of the epicondyle, torn collateral ligaments, fracture of the coronoid at its base with upward displacement of the brachialis muscle, tears of the front of the capsule, congenitally shallow trochlear notch of the ulna (the normal is a semi-circle or arc of 180 degrees), osteochondritis dissecans, and fracture of the medial condyle of the humerus. No case of rupture of the biceps tendon has been reported as a cause.

FIG. 1

Fracture of the base of the coronoid process with retraction of the brachialis muscle—one of the causes of recurrent dislocation of the elbow (Helferich).

The injury is not recorded in the large text-books of fractures and orthopaedic surgery except by Ombrédanne and Mathieu (1937) in their five-volume text-book. In Helferich's classic book (1899—translated from the third German edition of 1897 by J. Hutchinson, Jun.) there is a footnote by the translator describing, as a cause of recurrent dislocation of the shoulder according to Duplay and Reclus, " separation of the capsule and periosteum in one piece from the neck of the scapula " which appears to be the first description of the lesion emphasised by Bankart. Also in this book is the drawing (Fig. 1) of a coronoid process fractured at the base, not the tip, and drawn upwards with the brachialis muscle. Such an injury is one of the causes of recurrent dislocation of the elbow, but this is not stated in the text, although there is a description of the ease with which subluxation can be produced by manipulation in recent dislocations when the coronoid process is fractured.

Albert (1881) reported the case of a ten-year-old boy with an epicondylar fracture. No operation appears to have been performed for the recurring posterior dislocation. Heusner (1894) described a recurrent posterior dislocation of the ulna and anterior dislocation of the radius in a boy of thirteen years with a shallow trochlear notch and a fracture of the epicondyle. He deepened the notch but apparently with a rather unsatisfactory result as regards movements (von Staplemohr 1949). Von Rehn (1924) discussed the only reported anterior dislocation (age and sex of patient not stated) which he cured by a plastic operation on the front of the capsule, using two incisions to insert a free transplant of skin; there is a drawing of the operation and two photographs show normal function. Bloch's (1900) patient, by von Staplemohr's (1949) account, was a nineteen-year-old boy with a six years' history of repeated posterior dislocations. There was a loose body in the joint, apparently from an epicondylar fracture, which he removed, and the ligaments were slack.

Peritz (1924) is quoted by Sommer (1928) as having classified the causes of recurrent dislocation of the elbow and described a case. The patient was a twelve-year-old idiot boy and, according to von Staplemohr (1949), there was an old fracture of the medial condyle of the humerus with disturbance of growth, a small ulnar notch and laxity of ligaments. Sorrel (1935, quoted by Ombrédanne and Mathieu 1937) reported a postero-lateral dislocation in a boy of twelve years which he thought was the result of a torn medial ligament. He inserted a tibial graft posteriorly in the lower end of the humerus, and the free end of the graft lay along the lateral rim of the ulnar notch. But Reichenheim (1947) stated that Sorrel's patient was seventeen and had a congenital shallow trochlear notch in both ulnae caused by deficient coronoid processes. The right elbow had been dislocated on eight occasions and the left elbow on four occasions.

Knoflach (1935) carried out an elaborate repair of the capsule in a girl of fourteen years with a posterior recurrent dislocation arising from injury and with laxity of the ligaments but no congenital defect. There is an illustration of his operation in the article. A long band of fascia lata was inserted through lateral and medial incisions around the lower end of the humerus, encircling the front of the elbow joint in a cruciate or double spica effect. He obtained a good result.

Milch (1936) described bilateral recurrent dislocations in a boy of twelve years with congenital shallow trochlear notches; but he only operated on one side. He stated: " No one with whom the author has spoken has ever seen or heard of a similar case," which bears out the common view that this complaint is unusually rare. He inserted a boomerang-shaped tibial graft one inch in length into the coronoid process through a quarter-inch drill hole and thereby the curve of the notch was continued. At the end of the operation full flexion of the elbow was possible. Dzhanelidze and Usoltseva (1937) reported a case but no information is available according to Reichenheim. Gosman (1943) performed Milch's operation but used a square peg. The radiographs one year later showed some absorption of the peg but there had been no recurrence. The patient was a fifteen-year-old boy who had sustained dislocations since the age of three; there was no congenital abnormality but all the joints were hypermobile.

Reichenheim (1947) described an ingenious and physiological operation which he devised because he was unaware that any other procedure had been described. The patient, aged twenty-five years, had sustained an increasing number of posterior dislocations since the age of thirteen years. Radiographs showed striking shallowness of the trochlear notch of the ulna caused by an ununited fracture of the tip of the coronoid process, and also a shallow groove on the articular surface of the trochlea, attributed to osteochondritis dissecans. The biceps tendon was cut near its insertion and sutured to the tough periosteum on the anterior aspect of the coronoid process by two silver wire sutures. Six weeks later the power of supination and pronation seemed to be little diminished, and the only limitation was that of extension, which was to 170 degrees.

Wainwright (1947) used a flat cortical graft, measuring half an inch by a quarter of an inch by three-quarters of an inch, in the coronoid region for a recurrent posterior dislocation in a boy aged twelve years who had sustained five recurrent dislocations after the initial injury (he possibly had a shallow olecranon fossa). The bone graft was cut from the subcutaneous part of the upper border of the ulna; the elbow was immobilised for two months and there was a good result despite slow absorption of the graft.

Von Staplemohr's (1949) female patient aged thirty-four years had a shallow trochlear notch which he built up from an arc of 112 degrees and a depth of 6·5 millimetres to 155 degrees and 9 millimetres by two separate iliac grafts inserted into the olecranon process and coronoid of the ulna; the result one year later was satisfactory. His paper describes some of the earliest reported cases and is valuable because some of the original sources are not available in this country.

Kapel (1951) reported two patients with recurrent posterior dislocation, one of which

he operated on and cured by taking a strip from the biceps tendon and threading it through a quarter-inch drill hole in the plate of bone separating the coronoid and olecranon fossae; the tendon was then sutured to the tip of the olecranon. A central strip of triceps tendon was pulled through the same hole and sutured to the coronoid process. Thereby cruciate ligaments were constructed which had prevented any recurrence for seven years. The technique appears to be complicated.

CASE REPORT *

A man aged twenty-eight years had dislocated the left elbow posteriorly four times since childhood; and there had been two dislocations within the last four months. He had

FIG. 2

Author's case. Radiograph of elbow before operation, showing fracture of the coronoid process, the tip of which is retracted with the brachialis muscle.

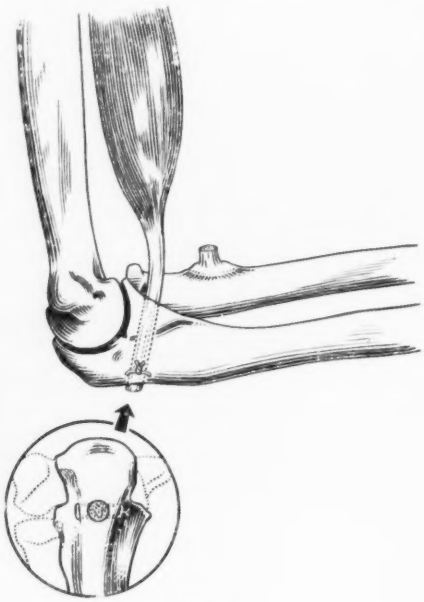

FIG. 3

Transplantation of biceps tendon. Reichenheim's technique modified by passing tendon through drill hole in coronoid to the subcutaneous border of the ulna, where it is sutured.

reduced one dislocation himself; and the other was pulled back by a hospital orderly. The last two dislocations followed simple injuries. He complained that the elbow felt insecure. On examination there was excessive mobility of the elbow. Radiographs showed non-union of a fracture of the coronoid process (Fig. 2) and osteochondritis dissecans of the trochlear surface of the humerus.

Operation—Reichenheim's method appeared to have the advantage that in a fall on the hand with the elbow extended there would be a powerful contracture of the biceps muscle to prevent a posterior dislocation; moreover the tendon lying in front of the trochlea and coronoid would act as a ligament restraining a tendency to posterior dislocation. The scarring caused by the attachment of the tendon to the base of the coronoid of the ulna would be an added factor as in recurrent dislocation of the shoulder treated by the Putti-Platt or Bankart's

* This patient was shown at the meeting of the Australian Orthopaedic Association in Melbourne in June 1951, at which the Sims Commonwealth Professor, Sir Reginald Watson-Jones, was present.

operation, or by any other procedure that causes adhesion in front, as Watson-Jones (1943) pointed out.

The coronoid region was displayed by Henry's exposure of the cubital fossa. The brachialis muscle was drawn up with the ununited coronoid process, which had broken off at the base; the fragment was removed. There was virtually no capsule in the vicinity. There was a groove on the trochlea resembling that seen on the posterior surface of the head of the humerus in recurrent dislocation of the shoulder or in osteochondritis dissecans. This appeared to be the result of dislocations, and also might encourage them. Repair of the capsule was impracticable. In the cadaver the normal capsule is thin, and dislocation is easily caused if strong hyperextension is first used to tear the capsule in front and the forearm is then pushed backwards with the elbow slightly flexed. The use of encircling fascia lata (Knoflach 1935), plastic repair of the capsule with skin or fascia (von Rehn 1924), construction of cruciate ligaments with strips from the biceps and triceps tendons (Kapel 1951), deepening

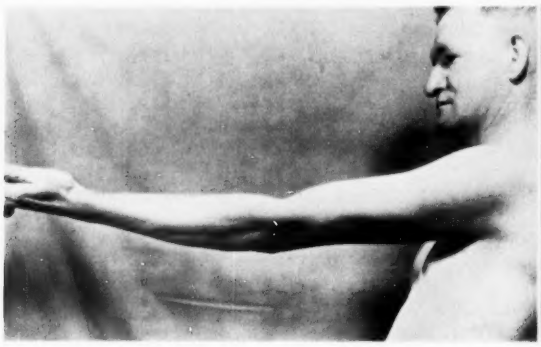

FIG. 4

FIG. 5

Photographs illustrating full range of flexion and extension after operation. There is no loss of power of supination.

of the trochlear notch by a bone graft (which is liable to be absorbed), are rather cumbersome. Operations on the cadaver showed that the main difficulty of Reichenheim's operation was to anchor the biceps tendon firmly to the base of the coronoid in the deep wound. But if the tendon were attached to the posterior surface of the olecranon, after being passed through a drill hole in the coronoid (Fig. 3), the attachment would be very strong. After this procedure on the cadaver the elbow could not be extended beyond 100 degrees because about one inch of tendon was buried in the drill hole in the ulna, and this meant a corresponding shortening of the tendon. The same difficulty was noticed at operation, and caused me anxiety as to whether the forearm could ever be fully extended; moreover the suturing of the skin incision was made difficult. But after four months there was full extension, and all movements were normal (Figs. 4 and 5). The power of supination was unaffected. There had been no recurrence two years after the operation.

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REPORT OF A CASE OF RECURRENT DISLOCATION OF THE ELBOW

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A man of twenty-four dislocated his left elbow when he fell backwards on to the outstretched hand. The dislocation was reduced on the spot; the method used is unknown but it is thought to have been by traction. Thereafter the elbow was dislocated repeatedly with different degrees of violence. The first recurrence was seven months after the first dislocation. The frequency with which dislocations recurred gradually increased until six years after the initial injury they were occurring every few days. He estimated that the elbow had been dislocated about thirty times. Reduction by a medical man had never been required: traction in extension reduced it without difficulty. Incidents which produced dislocation included pushing a trailer above his head, punching a punch-bag, leaning on the extended arm in bed, tossing pennies while playing "two-up," turning off the tap in a shower-bath, and swimming overarm—in this incident the elbow became dislocated when pulling through water and was reduced spontaneously when coming out. The patient was left-handed and was not conscious of instability except when dislocation actually took place.

On examination, the patient was well developed and of athletic type. There was no muscle wasting or weakness. Flexion-extension movements of the left elbow were of normal range, but there appeared to be some increase in lateral mobility. Under general anaesthesia the elbow was dislocated without difficulty, especially when the elbow was extended. The dislocation was backwards and upwards. Radiographs confirmed the displacement, and showed some loose bodies in the joint; there was no evidence of fracture of the coronoid process.

Operation (July 1949)—The technique to be described was devised by the writer to stabilise the joint. The elbow was exposed by a U-shaped incision with the limbs in the axis of the humerus on medial and lateral aspects, the loop of the incision passing around the upper part of the forearm on its posterior aspect. The ulnar nerve was isolated, freed and retracted. The joint capsule was inspected and found to be lax. The joint was opened and blood-stained fluid released. There was some lipping of the trochlea but no evidence of osteochondritis was seen. The capsule was plicated, and the joint further stabilised in the following manner. A strip of triceps tendon was dissected out, leaving its olecranon attachment intact. The strip was transposed to the medial aspect of the joint and buried in a bed made for it in the origin of the common extensor group anterior and distal to the medial epicondyle. There was an excess of length which allowed the tendon to be brought back to the olecranon more distally. As the triceps tendon was insufficiently developed to provide two strips, a strip of fascia lata was used to perform a similar function on the lateral aspect, being sutured to olecranon and lateral epicondyle. Essentially the effect of the operation was that new collateral ligaments were constructed, their attachments being in the approximate axis of movement of the humero-ulnar joint.

Post-operative treatment—The arm was immobilised at right angles in a plaster slab for three weeks. The only complication was the sloughing of a small area of skin due to the base of the "U" being too narrow in relation to the length of the limbs.

Progress—When last seen nearly two years after the operation the patient had had no further dislocations. There was some clicking in the joint, attributed to loose bodies not located at operation. There was a full range of painless movement of the elbow and power was normal.

Addendum—A further case of recurrent dislocation of the elbow has recently been seen by Mr J. Jens, in a boy of twelve years. An operation similar to that reported here was undertaken. So far there has been no further recurrence.

RECURRENT POSTERIOR DISLOCATION OF THE ELBOW JOINT IN A BOY

Report of a Case

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A boy ten years of age was seen in the orthopaedic clinic in May 1948 when he stated that he had first sustained a posterior dislocation of the left elbow joint two years before; at that time radiographs revealed no evidence of fracture (Fig. 1) and the dislocation had been reduced under a general anaesthetic. Redislocation occurred twice in the next year and on each occasion a general anaesthetic had been needed for reduction. Despite physical treatment designed to encourage muscular development, six further dislocations occurred up to the time of examination. The more recent dislocations had been reduced easily without anaesthesia. Clinical examination showed little difference between the two elbows either clinically or radiologically (Fig. 2).

Fig. 1

Radiograph of the elbow at the time of the initial injury, showing posterior dislocation but no evidence of fracture.

Treatment—At operation a semilunar piece of bone was taken from the upper part of the crest of the tibia and inserted into the coronoid process of the ulna (Fig. 3). The arm was then retained in a cuff and collar sling until the graft was judged to be incorporated. *Progress*—Apart from a crack-fracture of the donor bone two months after operation the subsequent history has been uneventful. The patient was last seen one year after operation. There has been no further dislocations and the graft, though somewhat smaller than originally (Fig. 4), appeared to be effective.

Fig. 2

Fig. 3

Fig. 4

Figure 2—Before operation. Figure 3—Two months after operation showing bone graft united to coronoid process. Figure 4—One year after operation. The graft has been partly absorbed but remains effective.

COMPLICATIONS AND DIFFICULTIES OF THE JUDET ARTHROPLASTY

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As far as we are aware arthroplasty of the Judet type was not performed in this country until 1950 and the first case was recorded in that year (King's College Hospital Gazette 1950). Most surgeons are agreed that this operation is a welcome advance in the surgery of the hip and that it may herald progress in the treatment of other stiff and painful joints. The experience of the Judet brothers is considerable and they have expounded the advantages of this form of arthroplasty (1950) and in a recent review (1952) of 400 patients the morbidity and complications were described. MacAusland (1951) was first to record the operation in America, but in his series of thirty-one cases there is no mention of any complications.

It is considered too early to assess the long-term value of the operation. The main object of this paper is to report measures adopted to prevent complications and discuss some of the difficulties of the operation and of the post-operative treatment. In a series of 100 operations, the following complications have occurred. Haematoma, 2*; dislocation, 5; new bone formation, 2; fracture of the stem, 2; deep vein thrombosis, 3. There was no case of deep wound infection. The series is unselected and represents the work of three surgeons and the operations were done in six different hospitals. The only patient no longer alive was a man of seventy-eight, who weighed 16 stone and who suffered from diabetes mellitus. He fractured the neck of his femur and died six months after replacement of the fractured head by a prosthesis.

Prophylactic measures—Great stress is laid on the prevention of operative shock. Gentleness, control of haemorrhage and skilful anaesthesia are important. Blood transfusion is given as a routine immediately before and during the operation. It is not usual for any patient to need more than one pint of blood, since anaemia is corrected before operation and blood loss is not great.

Chest complications are rare, and have usually taken the form of an exacerbation of chronic bronchitis. Advances in anaesthesia (which has always been a combination of the intravenous and inhalation types) have been instrumental in avoiding these complications. Breathing exercises before and after operation, and the routine use of systemic penicillin are measures of importance.

Deep vein thrombosis has occurred in three cases—a low incidence in view of the average age of the patients (fifty-four years), the site and magnitude of the operation and the post-operative immobilisation. It is feared that thrombosis may occur with equal frequency in the operated and normal limb and it is a sound measure to prevent pressure on the calf of the normal limb by placing sorbo cushions beneath it during the operation. Limb movements are encouraged immediately after operation. When thrombosis has occurred treatment with anticoagulants is begun promptly. In only one case has physiotherapy been held up for more than a few days. In this case, that of a man of sixty-five with osteoarthritis of both hips, operation was followed by deep vein thrombosis in the calf on the side of the operation and a small pulmonary embolus. A large haematoma formed in the anterior part of the thigh, possibly from the use of heparin. Treatment for the hip was delayed for several weeks and, at the time of his discharge, movements were limited.

* This figure represents only cases of large haematomata in which the clot has had to be evacuated surgically or has discharged spontaneously.

The importance of prophylactic measures is emphasised because most patients are elderly and are liable to suffer from the complications mentioned. Any local disturbance in the wound—sepsis, haematoma or delay in healing—may increase the severity of a systemic complication. Similarly the presence of general complications may be a factor in delayed wound healing.

Selection of patients—The development of a satisfactory technique by which complications are minimised has greatly widened the field for this operation. Very few patients are unsuitable by reason of age provided all members of the team are conversant with the pre-operative, operative and post-operative procedures. Senility, implying an inability for reasonably intelligent co-operation on the patient's part, is a contra-indication for this as for any other major reconstructive surgery.

LOCAL COMPLICATIONS

Haematoma—This may take the form either of a diffuse infiltration of the tissues or a local collection of blood. The former is recognised by oedema and thickening below the wound and in the buttock. It occurs commonly and may persist for as long as two months. It is a nuisance because it may delay the return of movement, but it is not serious. Careful haemostasis, the application of elastic adhesive bandages to support the outer part of the wound, a sandbag placed against the upper part of the thigh, or a spica of flannel bandage limit its severity. A localised haematoma has twice caused concern: in one patient (already quoted) the fluctuant area was incised and resutured; in the other the blood discharged spontaneously and infection was avoided.

In most operations an antero-lateral approach has been used and occasionally bleeding from the muscles separated from the lateral surface of the ilium has been troublesome. With care, however, this can be controlled and we do not consider that any other approach gives less trouble in this respect.

Wound infection—The avoidance of serious wound infection in this series may be partly explained by the routine use of antibiotics. It is considered that the easy approach, with limited dissection into muscle planes, and the shortness of operating time are important in reducing the possibility of sepsis. Superficial infection has occurred in a few cases, but in only one has healing been delayed beyond three weeks. On no occasion has deep infection occurred nor has it been necessary to remove a prosthesis for this reason. This is in contrast to figures reported for vitallium-cup arthroplasty. In Law's (1948) review of 182 of Smith-Petersen's cases superficial sepsis occurred in eight and deep sepsis in nine. Bickel and Babb (1948) reported ten cases of wound infection in 274 operations and the cup had to be removed in five. Gibson (1949) had to remove one cup in 100 cases because of sepsis.

Dislocation—Dislocation of the plastic head out of the acetabulum should be avoidable and the study of the five cases illustrates certain important features.

If the reconstruction restores nearly normal anatomical relationships, the new joint will be stable provided the limb is held in flexion, abduction and medial rotation, as can be demonstrated on the operating table before the wound is closed. Stability is due to two factors. First, the joint is a ball and socket which is, in itself, mechanically stable; and second, in the position of stability muscle pull helps to force the head into the acetabulum. In the course of healing, a strong fibrous pseudocapsule forms and this plays an important part but one which is secondary to the factors already mentioned.

When dislocation occurs the limb commonly rolls out by its own weight and the head comes forwards out of the acetabulum. Alternatively, with adduction of the limb the head rides upwards over the upper lip of the acetabulum. Minor degrees of this latter type of subluxation are occasionally seen: radiographs taken with the limb in abduction show the head in the acetabulum, but in adduction it lies just below the upper lip. This is not necessarily associated with instability and the result may be satisfactory. In practice, complete

dislocation results from a combination of lateral rotation and adduction (with one often predominating over the other) and is incompatible with good function.

The main features that may predispose to dislocation are mechanical and can be anticipated before operation. First in importance is the length of the femoral neck. When this is short—as in old subcapital fractures and in osteoarthritis with "mushrooming" of the head—reconstruction with the Judet prosthesis may result in an unstable joint. Lengthening of the neck by transposition of the greater trochanter is a recognised procedure but is seldom satisfactory. The use of a prosthesis with a neck attached may provide a solution to this problem, but as yet the method is still *sub judice*. Second, dislocation will tend to occur when the acetabulum is shallow and has a sloping roof. This is by no means so difficult a proposition as the short neck and it can usually be dealt with satisfactorily by extensive reaming with the Smith-Petersen instruments. Judet's reamer is not adequate for shaping the acetabulum and should be reserved for removing soft tissue. In cases of congenital dislocation reaming of the acetabulum may not be sufficient to give stability and it may be necessary to construct an upper lip (D'Aubigné 1952). A third mechanical factor can be the result of a technical error during the operation. If the prosthesis is inserted in an exaggerated valgus position, dislocation will occur more readily during adduction. A few degrees of valgus are probably helpful because with weight bearing the strain will be taken down the length of the prosthesis rather than across it, but the greatest stability is achieved when the stem is inserted exactly down the middle of the neck and parallel with its edges.

During operation care should be taken to avoid the muscle damage which may follow an unnecessarily wide exposure or vigorous retraction. If this occurs delay in recovery of muscle tone may be a secondary factor contributing towards dislocation. The straight head of the rectus femoris muscle should be preserved and stripping of the iliac crest should be limited to a distance of two or three inches. In most cases the capsule has been excised widely, leaving only a strip one inch wide posteriorly. Although repair of the capsule may be desirable theoretically in this operation it is difficult technically, even in recent fractures. Furthermore it is still generally held that capsulectomy is advisable if pain is to be relieved. At the end of the operation and before the wound is closed it is helpful to assess the range of movement and the stability of the joint. If dislocation occurs readily after a few degrees of lateral rotation or adduction special care will be needed during the post-operative treatment.

Dislocation may occur soon after operation from failure to maintain the position of stability. The limb should be carefully held by an assistant at the end of the operation and while the patient is being returned to the ward. When he is back in bed skin or skeletal traction is set up. If strapping is used it is important to apply a cross-piece at the level of the knee to control rotation. The limb is suspended in slings or, if a tibial pin is used, in a Tulloch Brown splint. Weights or springs are used to maintain the required position.

Exercises for the sound limb and for the knee, ankle and toes on the side of the operation are begun straight away, but hip movement—apart from that which takes place during sitting and lying—is not actively encouraged for two weeks. In the early stages more attention should be paid to the maintenance of muscle tone by static contractions rather than to regaining the range of movement: this is usually restored easily. It is possible that too early or too vigorous activity might result in dislocation. Traction is maintained for from three to six weeks, after which the patient is allowed out of bed. Weight bearing is begun five to seven weeks after operation in the average case: at first with crutches and as soon as possible with sticks. Dislocation is unlikely to occur after the fifth week, although in one case it was first noticed in the seventh week (Case 2).

In general, then, it is fair to conclude that mechanical factors such as shortness of the neck, shallowness of the acetabulum and the insertion of the prosthesis in an excessively valgus position are the prime causes of dislocation. Excision of the capsule and delay in recovery of muscle tone probably play only a secondary part.

The diagnosis of dislocation is not difficult. The patient complains of pain in the hip, but is not aware that dislocation has occurred. In none of our cases has dislocation been observed to follow any sudden movement or change in position. Hip movements are limited and the leg is rolled out. There is a characteristic alteration in the shape of the thigh, but bony landmarks are difficult to feel because of thickening around the joint. Diagnosis is confirmed by radiography. Treatment should not be delayed: the dislocation is reduced as soon as possible, under a general anaesthetic, by traction, abduction and medial rotation. The resilience of the soft parts at this stage of repair makes it difficult to be sure if reduction has occurred after manipulation and it is not possible to feel a "click" as the head enters the acetabulum. Reduction is confirmed radiographically. In our five cases reduction was achieved without difficulty. The problem of maintaining reduction is, however, not so easy. Rotation must be controlled and a long hip spica is probably the most satisfactory method. Other methods consist of holding both legs in wide abduction with skin traction or with short plasters and a cross bar. Immobilisation for three or four weeks should be enough to ensure stability, but once complete dislocation has occurred the mechanical factors that caused it persist and there will be a tendency to recurrence. The practical difficulties are discussed in the five case reports given below.

Case 1—Woman aged fifty-eight. Subcapital fracture of the right femur. A Smith-Petersen nail was inserted two weeks after injury, but the fracture failed to unite and radiographs showed absorption of the neck and extrusion of the nail. At operation the neck was found to be short and part of the greater trochanter had to be removed before the plastic head could be fitted. Five weeks after the operation she complained of pain in the hip and the plastic head was found to be dislocated. It was reduced and the position was maintained by skin traction. Two weeks later dislocation recurred. It was again reduced and a hip spica was applied. After a further four weeks radiographs again showed redislocation. The original operation wound was reopened and the instability of the joint was easily demonstrated. The plastic head remained securely fixed on the femur. The acetabulum was enlarged and the greater trochanter detached and transferred one inch down the shaft of the femur, being refixed with a screw. Reduction now appeared stable, but three and a half weeks later radiographs showed that dislocation had once more recurred. No further attempts at reduction were considered. When discharged she was walking well with a caliper which she has since been able to give up.

Comment—This case illustrates the difficulties of maintaining stability when the femoral neck is short. An attempt to remedy this by transplantation of the greater trochanter failed. In this case the large stature and heavy build of the patient added to the difficulties of treatment.

Case 2—Man aged forty-three, suffering from dysplasia epiphysialis multiplex. Both hip joints were affected and he developed a painful secondary osteoarthritis on the left side (Fig. 1). At operation extensive removal of the capsule was carried out: the acetabulum was not touched. The plastic head seemed stable while the patient was on the operating table. Seven weeks after operation, after he had been walking with crutches for two weeks, it was found that the plastic head had subluxated (Fig. 2). The date when the subluxation occurred is unknown, but ten days before he had complained of some pain in the hip. The subluxation was reduced under a general anaesthetic and the joint was stable in abduction and medial rotation. This position was held by two below-knee plasters and a cross bar. Two weeks later a single hip spica was applied, reduction still being maintained (Fig. 3). He was allowed to walk in this plaster, which was removed seven weeks after the subluxation was reduced. Subsequently he walked with crutches and the subluxation did not recur.

Comment—In this case the abnormal shape of the acetabulum and the shortness of the neck were basic factors in causing dislocation. The displacement was not so complete as in Case 1 and reduction is still maintained. It is likely that a minor degree of subluxation occurred before the diagnosis was made and produced symptoms only on weight bearing.

Case 3—Man aged seventy-two. Chronic non-specific inflammatory arthritis with avascular necrosis of the femoral head, of unknown etiology (Fig. 4). At operation the capsule of the hip joint was grossly distended with fluid and the synovial membrane was polypoid. The head was removed and a plastic prosthesis fitted (Fig. 5). After operation he was extremely ill, developing uraemia, broncho-pneumonia and a deep vein thrombosis of the right calf. His condition slowly improved. Three weeks after operation the large effusion had re-formed and the plastic head

FIG. 1

Case 2—Before operation. Osteoarthritic changes in the left hip secondary to dysplasia epiphysialis multiplex. The acetabulum is shallow.

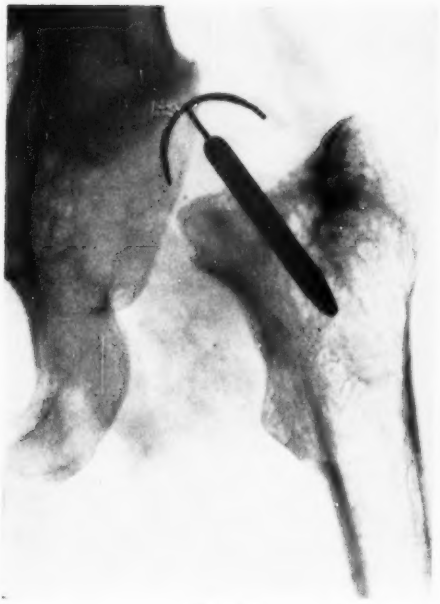

FIG. 2

FIG. 3

Case 2. Figure 2—Six weeks after operation, showing subluxation of the plastic head. The stump of femoral neck is very short. Figure 3—After manipulative reduction the hip remained stable.

FIG. 4

Case 3—Before operation. Avascular necrosis of the right femoral head of unknown etiology.

FIG. 5

FIG. 6

Case 3. Figure 5—After operation. The neck is of adequate length. Figure 6—Three weeks later. Complete dislocation of the plastic head. The shallow acetabulum and rapid collection of fluid were the contributing factors. Note the extreme lateral rotation.

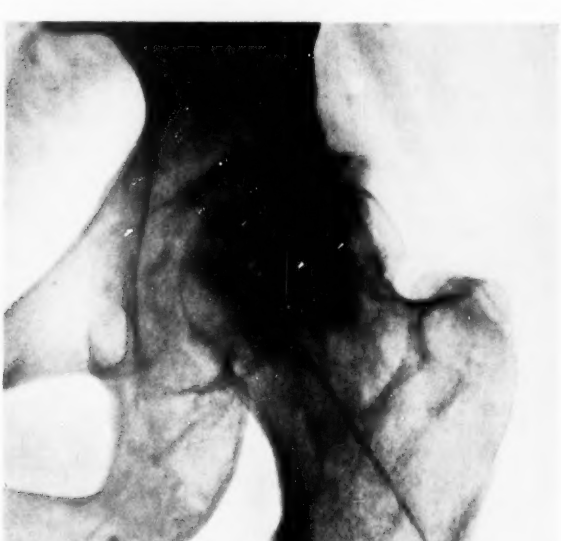

FIG. 7

Case 4—Before operation. Avascular necrosis of the left femoral head following a subcapital fracture. Note track of Smith-Petersen nail.

FIG. 8

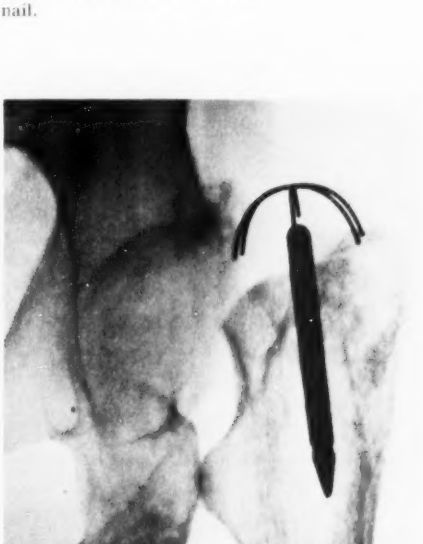

FIG. 9

Case 4. Figure 8—After operation. The short neck and exaggerated valgus position of the prosthesis are well shown. Figure 9—Two weeks later. Dislocation has occurred.

had dislocated (Fig. 6). Reduction was accomplished easily and the limb was held in a short hip spica. At the same time 60 cubic centimetres of blood-stained fluid was aspirated from the hip joint. Eleven days later dislocation recurred while the limb was still in plaster. He was a feeble old man and no further operative treatment was considered. A caliper was ordered. Ten weeks after operation he developed a right-sided hemiplegia from cerebral thrombosis.

Comment—In this case the neck was of sufficient length but the acetabulum shallow. Rapid distension of the hip joint with fluid and difficulty in post-operative care, because of his poor general health, were factors leading to dislocation. Figures 2 and 6 illustrate the two types of dislocation, one occurring in adduction and the other in lateral rotation.

Case 4—Woman aged fifty-seven. Subcapital fracture of the left femur treated initially by Smith-Petersen nail. The hip became painful and the nail was removed. Pain and disability increased and movements became restricted to 10 degrees of flexion. Radiographs showed avascular necrosis of the femoral head (Fig. 7). Prosthetic replacement of the femoral head was undertaken. Post-operative radiographs showed a valgus insertion of the prosthesis (Fig. 8). Three weeks later the plastic head was found to be dislocated (Fig. 9). Reduction was easy; the position was maintained with plaster boots and a cross bar. After three weeks the head was still in the acetabulum and the fixation was removed. One week later dislocation recurred. No further attempt at reduction was made and at a second operation the plastic head was removed and the neck of the femur trimmed leaving an " excision " type of pseudarthrosis.

Comment—In this case the femoral neck was rather short, but the valgus insertion of the prosthesis was probably the deciding factor in producing the dislocation.

Case 5—Man aged sixty-eight years. Ununited fracture of neck of left femur. At operation the femoral head was replaced by a prosthesis. Post-operative progress seemed satisfactory; ten days later radiographs showed that the plastic head had dislocated. Reduction was accomplished and maintained by skin traction with both legs in wide abduction. There has been no recurrence.

Comment—A short femoral neck was again a factor in producing the dislocation, but its early occurrence was precipitated by difficulties in controlling the position of the leg after operation.

Discussion—The incidence of dislocation in this series is 5 per cent. Although it has been dealt with at length it is not confined to the Judet type of operation. It occurs also after cup arthroplasty, when it presents an equally difficult problem. In Law's (1948) series dislocation was reported in 3·3 per cent of cases; in Gibson's (1949) in 3 per cent, and in Bickel and Babb's (1948) in 1·1 per cent. No detailed references to the instances of complications of the Judets' type of operation have been discussed in the literature except in papers by Thomson (1952) and Judet and Judet (1952). Thomson used a " light bulb " type of plastic head fixed to a Smith-Petersen nail. In twelve cases he noted that the only troublesome complication was dislocation, which occurred three times. In two of these cases the patients were hemiplegics with adductor spasm. In the third of these cases the prosthesis subluxated towards the upper edge of the acetabulum but the patient walks with a stable hip. This incidence is higher than need ordinarily be expected. It is clear that every effort must be made to prevent dislocation, and measures which are found to be helpful before, during and after operation have been discussed. When dislocation does occur, reduction should be attempted, but it is emphasised that the mechanical factors causing it will still be present and so permanent stability is difficult to achieve. It can be maintained when there has been only a small degree of subluxation or when dislocation has resulted from some difficulty during the immediate post-operative period, the reconstruction being mechanically satisfactory. Otherwise the complication is serious and further attempts to stabilise the joint may not be successful.

New bone formation—In this type of operation new bone formation should be less common than with cup arthroplasty. In this series it occurred in 2 per cent of cases. Bickel and Babb reported the low incidence of 1·4 per cent. In Law's series, however, " hypertrophic changes " were observed in 9·3 per cent of cases. Two factors are largely responsible for the low incidence of this complication in Judet's type of operation as opposed to cup arthroplasty. First, the

muscles are stripped from the iliac crest for only a short distance. Secondly, in the cup operation there is greater chance of bone fragments being left behind in the recesses of the wound.

Case 6—Man aged forty-one. Osteoarthritis of right hip (Fig. 10), for which Judet-type arthroplasty was undertaken (Fig. 11). Everything was straightforward until three months after operation, when he complained of discomfort in the hip and noticed that it was becoming stiff. The range

FIG. 10

FIG. 11

Case 6. Figure 10—Before operation. Osteoarthritis. Figure 11—After operation.

FIG. 12

FIG. 13

Case 6. Figure 12—Consolidated plaque of new bone six months after operation. Figure 13—Three months after excision of new bone.

of flexion had decreased from 80 degrees to 40 degrees and no other movement was present. Radiographs showed that new bone had formed between the greater trochanter and the upper lip of the acetabulum. All treatment was stopped and he was kept under observation. Four months later the new bone had consolidated completely (Fig. 12). Six months after the first operation the joint was re-explored and a large plaque of new bone was found in the gluteus minimus and in the capsule over the front of the joint. It was firmly attached to the greater trochanter and

had to be removed with an osteotome. The plastic head was left in place. The limb was suspended in the usual manner but hip movements were not begun till nine weeks after operation. On discharge he was walking well with two sticks and his range of movement was increasing. There was no evidence of further new bone formation (Fig. 13).

Case 7—Woman aged eighty-one. Subcapital fracture of right femur treated unsuccessfully by the insertion of a Smith-Petersen nail. The femoral head was replaced by a prosthesis. Her progress was slow as she made little attempt to co-operate, but when discharged four and a half months after operation she was able to walk unaided. Radiographs at that time showed the formation of excessive new bone around the hip joint. No further treatment was considered in this case in view of her age and inability to co-operate. She was later readmitted with a fracture of a shaft of the same femur.

Fracture of the stem—It may be that fracture of the stem of the prosthesis is one of the disadvantages of this operation. So far, in this series with an average follow-up of ten months, it has occurred in only two cases. The fact that any material is liable to fatigue-fracture in the course of time makes it difficult to assess the importance of this complication until

FIG. 14

FIG. 15

Case 8. Figure 14—Spontaneous fracture of the metal stem of the prosthesis four months after operation. Figure 15—The plastic head after removal.

the operation has been carried out for ten years or more. In Judet and Judet's original series the incidence of fracture of the stem was high, but after a metal insert was introduced into the prosthesis they claim that there have been no further fractures (Judet and Judet 1950). In the present series there has been a metal stem in every prosthesis used.

Case 8—Man aged sixty-six. Osteoarthritis of right hip. Replacement of the femoral head by a prosthesis was undertaken. He was discharged three months after operation. When seen four months after the original operation he complained of having had pain in the hip during the previous week. It had not come on suddenly or been related to any injury. He was unable to take weight on the limb, and radiographs showed a fracture through the metal stem of the prosthesis (Fig. 14). The joint was re-explored. There was much fibrosis around the joint and a strong new capsule had formed. The broken plastic head was removed and a new one, with a longer stem, inserted. He made good progress and is walking without pain.

Comment—Figure 15 shows the plastic head after removal. The clean fracture through the stem is well illustrated. It seems likely that it was due either to a flaw in the metal or to a fatigue fracture. It is clear, in any event, that the fracture was spontaneous and not related to any injury. The following case is in contrast to this.

Case 9—Woman aged sixty. Ununited subcapital fracture of left femur with avascular necrosis. Prosthetic replacement of the femoral head was carried out (Fig. 16). She was discharged five weeks after operation with a good range of movement. Fourteen months later she tripped and fell on a staircase. The hip became painful and she could only get about with difficulty. Radiographs

FIG. 16

FIG. 17

Case 9. Figure 16—After operation. Figure 17—Fracture of the lower border of the femoral neck after a fall fifteen months after operation.

FIG. 18

FIG. 19

Case 9. Figure 18—The plastic head after removal showing fragmentation of the plastic stem although the metal insert is intact. Figure 19—After insertion of a new prosthesis in a greater degree of valgus.

a month later showed a fracture of the lower border of the neck of the femur and the plastic head now in a varus position (Fig. 17). The joint was re-explored. The plastic part of the prosthesis was found to be broken into several pieces, although the metal insert was intact (Fig. 18). A loose piece of bone was found to have been broken from the lower border of the neck. The plastic head and the pieces of the stem were removed. A new head was inserted in a more valgus position and

the defect in the neck packed with bone chips taken from the ilium (Fig. 19). Her progress has been satisfactory, but she was given a caliper during the early stages of weight bearing.

Comment—It is fair to suggest that this fracture was produced by a mechanism similar to that which would cause a fracture of the neck of the femur. Even if a prosthesis of metal had been used the bone might have broken and a similar condition occurred. This plastic head had been in place for fifteen months, and when it was removed a certain amount of flattening and wear could be seen on its surface. It is probable that wear occurs in all cases and its consequences after a period of years are not easy to predict.

Discussion—Experience of the treatment of this complication has not been sufficient to allow any definite statements to be made. In the two cases described the operations were carried out *per secundum artem*, it being felt that replacement of the broken prosthesis with a new one would be more satisfactory than converting the joint into a pseudarthrosis.

OPERATIVE DIFFICULTIES

The peculiar difficulties of this operation arise in the removal of the head and the shaping and boring of the neck of the femur.

The head is cut off through its base with an osteotome and this may be done before or after dislocation of the joint, according to personal choice. When there is strong fibrous ankylosis separation of the head while it is still in the acetabulum and subsequent removal with a corkscrew produces less disturbance. Once the head has been removed, the neck is prepared to receive the stem and collar of the plastic head. It is not difficult to choose the correct line, but if the bone is very soft, as it often is in cases of recent fracture, the neck may crumble, making a satisfactory fit impossible. Similarly in cases of osteoarthritis, cysts may be present and will result in defects of the neck. It is surprising that, unless these defects are very large, the head can be fitted firmly and a good functional result obtained. A defect in the lower border of the neck may be overcome by packing the space with bone chips, but this is not entirely satisfactory. In only one case, however, has this deficiency been insuperable. A man of fifty-nine with gross osteoarthritis of the left hip was found at operation to have advanced cystic changes in the femoral neck. Post-operative radiographs showed the head in 90 degrees of varus and with very little bony support below it. He has been fitted with a caliper.

In another case a woman of sixty-two, with gross bilateral osteoarthritis, had a successful plastic replacement on one side. When the second side was operated on, the neck was found to be so short that it was impossible to fit a plastic head and she was left with a pseudarthrosis of the "excision" type.

It is sometimes difficult to dislocate the hip at operation. This was particularly so in one case, that of a man of sixty with osteoarthritis associated with Paget's disease. In another case, in which there were gross hypertrophic changes following central dislocation, the head was so firmly fixed in the acetabulum that it could not be removed, after division, with a "corkscrew." A new acetabulum was reamed out of the head itself. The functional result has been excellent.

DISCUSSION

There is little doubt that the study of these local complications has been greatly helped by having some radio-opaque markers in the prosthesis. A complete metallic head and stem is too dense and makes assessment difficult. It is hoped that in due course a plastic with a suitable radio-opaque element will be found, for at present details of fractures of the plastic can only be known at operation.

Evidence soon established that this operation was less of an ordeal for the patient and surgeon and that comfort after operation was far greater than with the other forms of hip arthroplasty. It is not intended, however, to indicate the function achieved by this operation and in due course it is hoped to publish the late results.

SUMMARY

1. Complications of the Judet arthroplasty are few.
2. The antero-lateral approach provides good access to the joint for insertion of the prosthesis.
3. Details of treatment before and after operation are described and their importance in limiting complications is emphasised.
4. The complications that have been encountered—including dislocation and fracture of the stem—are described and factors in their causation are discussed.
5. Study of the mechanical state of the new joint and the diagnosis of complications are aided by radio-opaque markers in the prosthesis.

We wish to thank other members of the department for their collaboration and help in the practice and development of this type of arthroplasty, especially Mr H. L.-C. Wood and Mr R. C. F. Catterall.

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USE OF ACRYLIC PROSTHESIS IN THE TREATMENT OF FRACTURE OF THE HEAD OF THE RADIUS

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The results of excision of the head of the radius for fracture are not universally good. Local formation of new bone and proximal displacement of the radial shaft are two factors that may impair the function of the elbow. Formation of new bone at the site of resection of the radial head may occur despite careful removal of all loose fragments of bone and periosteal shreds. The interosseous membrane, with its fibres running obliquely from the radial shaft to the ulnar shaft, tends to prevent proximal displacement of the radius. Nevertheless the pull of the muscles combined with external forces acting through the radius eventually produces stretching of the interosseous membrane. Proximal displacement of the radius results in widening of the distal radio-ulnar joint and may lead to pain and weakness at that point. It may be observed clinically by prominence of the lower end of the ulna at the wrist and in radial deviation of the hand.

The advent of acrylic resin has made the substitution of an artificial head for the damaged and excised head a practical proposition. The work of Judet and Judet (1950) on the hip joint has shown that this material is unaltered by long stay in the body, that it is not attacked by organic acids, and that little, if any, osteoporosis occurs at the site of contact of the bone with the plastic.

Fractures of the head of the radius may be considered under three types. The first type, the simple crack, and the second type, in which the circumference of the head has been moderately increased by comminution but no loose pieces are present, respond well to conservative treatment. It is only in the third type, in which there is marked displacement of bony fragments, that operative removal of the damaged head is indicated. Surgeons have remarked on the frequency with which damage to the capitulum is seen at operation, though not visible in the radiographs, and this may be an added factor in favour of exposing the joint.

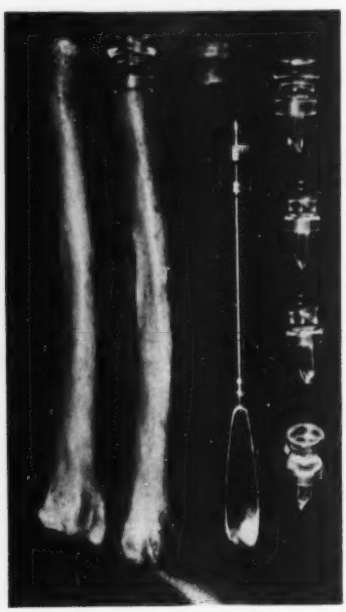

Fig. 1

Acrylic radial heads and crown saw for cutting neck of radius to size. The heads are in three sizes—$\frac{3}{4}$ inch, $\frac{7}{8}$ inch and 1 inch. The internal diameter of each cap and of the crown saw is $\frac{5}{8}$ inch.

TECHNIQUE OF OPERATION

The posterior approach described by Boyd (1940) offers certain advantages when the insertion of an acrylic head is contemplated. It gives a more ample exposure and enables the operator more easily to ream the severed neck with the crown saw and thus to fit the acrylic head. Moreover the repair of the annular ligament is more easily carried out when it is cut close to its attachment to the ulna than when it is sectioned farther out on its periphery. In this exposure the anconeus and the supinator are separated from their attachments to the ulna, and the entire mass, which includes the posterior branch of the radial nerve, is retracted laterally. *Resection and replacement of the head*—The neck is cut through with a Gigli's thread

FIG. 2

Post-operative radiographs with prosthesis in place. This patient has a full range of flexion, extension, pronation and supination.

saw and the severed neck reamed with the crown saw (Fig. 1). The acrylic head should then fit tightly on the neck, the base of the head lying just free of the prominence of the radial tuberosity. A set of acrylic radial heads is shown in Figure 1, and illustrative clinical radiographs are reproduced in Figure 2.

DISCUSSION

Substitution of an acrylic head may prove to have a small but useful place in the treatment of fractures of the head of the radius requiring excision. The ideal case would be that in which the radial head is shattered but the capitulum is not seriously damaged. With experience its use may be widened.

The number of cases so far treated is too small to draw any definite conclusions. Nevertheless it seems possible that by capping the sectioned radial neck the artificial head may help to limit the formation of new bone. It will certainly prevent proximal displacement of the radial shaft and consequent strain on the distal radio-ulnar joint. It will maintain the normal carrying angle of the elbow and prevent cubitus valgus.

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THE DIAGNOSIS OF SHOULDER LESIONS DUE TO INJURIES OF THE ROTATOR CUFF

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The diagnosis of tears of the rotator cuff of the shoulder by clinical examination alone presents considerable difficulty. It may be remembered that in diagnosing complete ruptures of the supraspinatus, Codman (1934) confirmed his diagnosis at operation in twenty-one cases; in nine he was wrong. His criteria for operation were severe and demanded certain physical signs, which probably meant that in many quite serious tears no operation was attempted.

Fig. 1

Normal arthrogram.

Although it is possible that surgeons to-day may be more accurate in their diagnosis on physical signs alone, it is obvious that further help is required. It may also be recalled that although Codman's interest and renown were so great, he was never able to operate immediately after the injury because of late diagnosis, but he maintained that early suture should be a simple and successful operation. "Delay means retraction of the tendon and a much more serious problem."

In spite of the ingenious methods of repairing retracted tendons described by Bosworth (1944) and McLaughlin (1944), it is evident that early, as well as accurate, diagnosis is desirable. This paper is an attempt to assess the value of two procedures: procaine injection

of the tender area over the tip of the humeral tuberosity in recent injuries, and arthrography. The value of the latter has been shown in the excellent papers of Lindblom and Palmer (1939).

Procaine injection—Patients suspected of a recent injury of the rotator cuff on clinical grounds are subjected to an injection of procaine. If this restores the power of voluntary abduction, up to 150 degrees or more, it is considered that a major lesion is unlikely and treatment is conservative. If injection does not increase the voluntary range, arthrography is performed.

Arthrography—The technique involves the insertion of a short-bevelled needle through the clean skin one inch in front of the acromio-clavicular joint. The needle is directed downwards and backwards into the cartilage of the humeral head. Thirty per cent diodone is injected under radiographic control. If the opaque fluid enters the joint, but immediately flows out into the subacromial bursa, it is considered that there must be a large tear requiring operative repair (Figs. 1 and 2).

Reliability of the tests—Procaine injection is confined to early lesions. In this series, fourteen

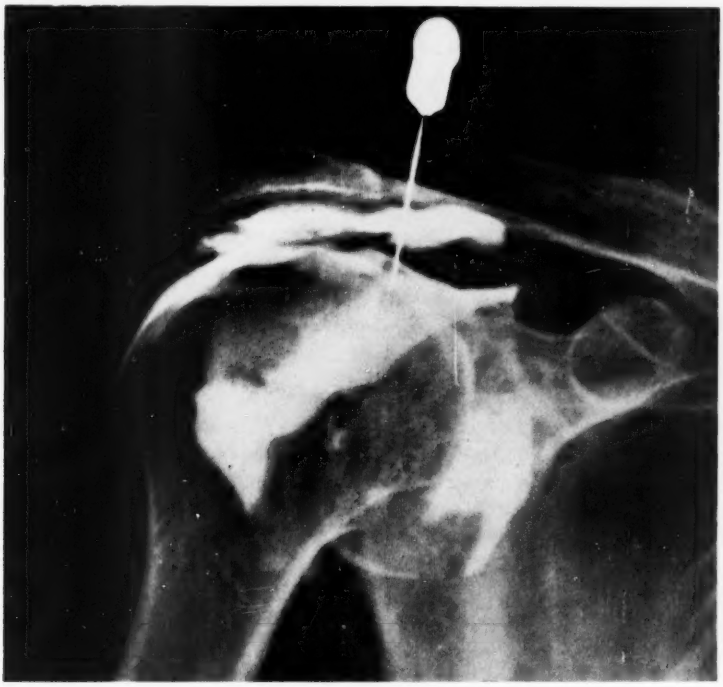

FIG. 2

Arthrogram showing large tear of the supraspinatus. The opaque medium has entered the subacromial bursa through the rent.

out of twenty-eight shoulders responded by an increased range; eleven did not; three were equivocal (Table I). Of the fourteen that had increased range twelve recovered completely. Of the other two, which were operated on, one showed a recent extension of a small tear; the second a small tear and stiff shoulder. Of the eleven shoulders that did not respond, seven had a large tear at operation or did not recover. Of the three equivocal cases, two recovered, one did not. This procedure, therefore, gives a good, though not completely accurate, indication, and may save an unnecessary exploration.

Arthrography was employed for forty-two suspected major tears (Table II). Of these, twenty-two were considered to show major tears; fifteen were subjected to operation; seven

either refused or were unsuitable on account of age or other factors. In fourteen operations the arthrogram findings were confirmed. In the exceptional case the patient had probably dislocated his shoulder and had contused the supraspinatus. More than half of these patients recovered good movement and power and lost their pain. The seven patients who did not have operation failed in every case to recover and only two improved. All cases have been

TABLE I

PROCAINE INJECTION OF RECENT INJURIES (TWENTY-EIGHT CASES)

	Number of cases	Complete recovery	No recovery or operation performed
Positive response	14	12	2
No response .	11	4	7
Uncertain . .	3	2	1

TABLE II

ARTHROGRAPHY (FORTY-TWO CASES)

Arthrographic diagnosis	Number of cases	Operation		No operation	
		Diagnosis proved	Diagnosis disproved	Recovered	No recovery
Large tear	22	14	1	0	7
No tear .	20	2	0	15	3

followed up for at least one year. A positive arthrogram finding is thus an almost certain indication of a major tear requiring operation, and can be obtained without delay.

A negative arthrogram, or a plain radiograph showing an avulsion crack in the greater tuberosity, was obtained on twenty occasions. Fifteen of these patients recovered completely; two others were operated on for pain and the presence of a minor lesion was confirmed. Negative arthrography is, therefore, a good contra-indication to operation, unless other factors require it.

My thanks are due to Mr A. W. Lipmann Kessel and Mr J. G. Taylor for their assistance in this work.

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NAVICULO-CUNEIFORM FUSION IN THE TREATMENT OF FLAT FOOT*

EWEN A. JACK, EDINBURGH, SCOTLAND

Flat foot, or the unstable everted foot, is a highly controversial subject on several issues. As a prelude to this paper it is therefore necessary to assert two main premises on which the work reported here has been based. 1) Flat foot of severe degree is a disabling condition which causes restriction of activity in young adults and induces morbidity in later life. Correction of the deformity by operation in young patients is worth while if it is possible.

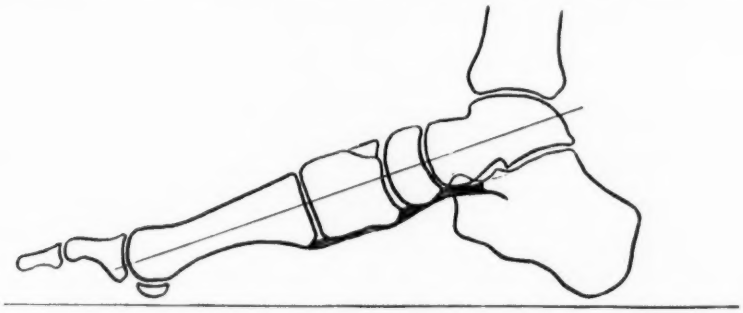

FIG. 1

In the normal weight-bearing foot the axes of talus, navicular, medial cuneiform and first metatarsal form a straight line.

2) The medial longitudinal arch of the foot and therefore the posture of the foot depend upon the intrinsic structure of the bones and joints and the integrity of the plantar ligaments. Muscles are concerned solely with balance and the protection of ligaments from abnormal stress. Though they are able temporarily to lift a sagging arch, they cannot constantly maintain an arch in which there is a ligamentous or bony defect. This latter view is perhaps the most controversial. It gains support from the material in this paper.

ANATOMICAL TYPES OF FLAT FOOT

Whatever theory of posture is held, it cannot be denied that in flat foot the long arch sags. In the normal weight-bearing foot the axes of talus, navicular, medial cuneiform and first metatarsal form a straight line (Fig. 1). Theoretically sag may occur at one or all of three points—the three joints which link the segments of the arch.

It is possible to demonstrate radiologically the anatomical situation of the break in the arch. Lateral radiographs of the foot must be taken with the patient standing erect with his muscles relaxed as far as possible. Collaboration by the radiographer is essential

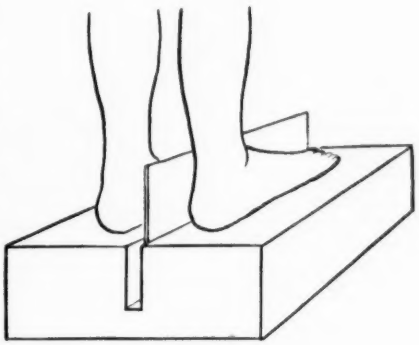

FIG. 2

Simple stand and cassette holder for lateral radiography.

* Paper read at the Annual Meeting of the British Orthopaedic Association in Edinburgh, October 1951.

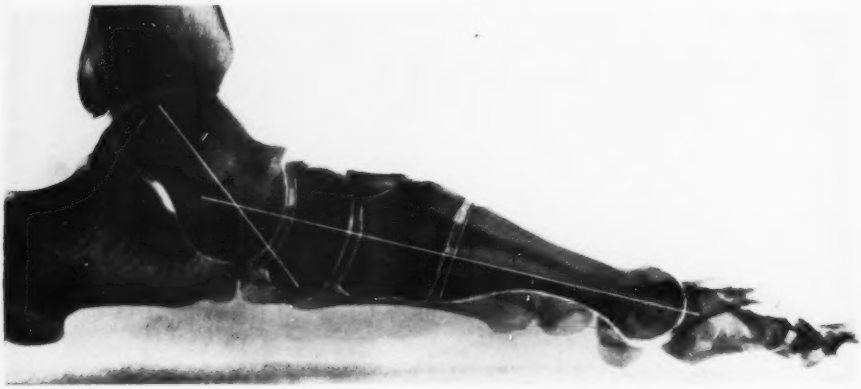

FIG. 3

FIG. 4

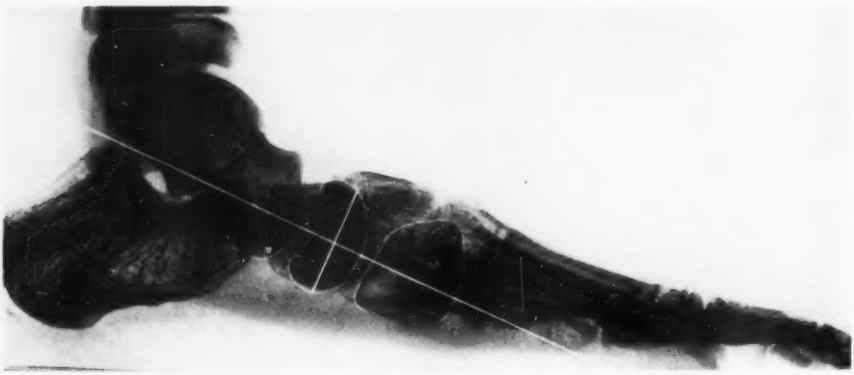

FIG. 5

The three anatomical types of flat foot. Figure 3—Talo-navicular break ("perpendicular" talus). The axes of navicular, medial cuneiform and first metatarsal remain in line. Figure 4—Naviculo-cuneiform break. The axis of the navicular corresponds to that of talus but lies well below the medial cuneiform and first metatarsal. Figure 5—Combined break. Both talo-navicular and naviculo-cuneiform joints are faulty. The axis of the navicular lies below the talus and first metatarsal segment.

in ensuring the relaxed position when exposure is made. It is helpful to have a simple stand and cassette holder so that a standard position and technique can be adopted (Fig. 2). Investigation in this way shows that the unstable foot can be classified into three distinct anatomical types. The metatarso-cuneiform joint never gives way. It is a flat stable joint with a small range of movement. The break may occur at the talo-navicular joint alone (the so-called perpendicular talus deformity), it may occur at the naviculo-cuneiform joint alone, or there may be relaxation at both these joints in a combined sag. Determination of the site of the break in the arch is most reliably achieved by drawing a line through the axis of the navicular. It can then be seen whether angulation occurs proximal or distal to the navicular, or at both situations (Figs. 3 to 5).

Assessment of the relative frequency of these anatomical types is not easy. Of a very large number of patients with flat foot of varying degree a comparatively small proportion has been investigated. The impression has been gained that the naviculo-cuneiform defect is more common than the other types.

Clinical examination—Clinically it is difficult to detect at which joint the fault lies. A simple test referred to as the "toe-raising test" gives an indication but is not entirely reliable (Fig. 6). While the patient stands with weight on both feet, the great toe is fully dorsiflexed. This manoeuvre restores the arch and gives stable posture in all cases of naviculo-cuneiform break (Figs. 7 and 8), and in most combined breaks, but it does not do so when the talus is perpendicular. There is then insufficiemt leverage to force the navicular under the head of the talus. The efficiency of the toe-raising test is vitiated by a tight tendo calcaneus—an element in the deformity to be mentioned later.

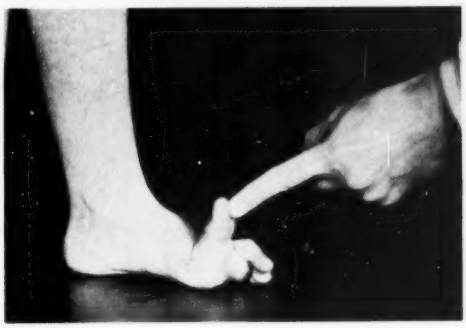

FIG. 6

Toe raising test. Elevation of the great toe balances up the foot in naviculo-cuneiform break and in most combined breaks.

An interesting anatomical point emerges in connection with this toe-raising test. If the long arch is incompetent for any reason, the foot rolls medially and the calcaneum becomes everted at the subtalar joint. Eversion is not a pure movement in one plane, but is associated with rotation about the head of the talus, and produces a valgus position of the foot in relation to the vertical axis of the talus. Therefore even when the arch sags at the naviculo-cuneiform joint alone, the valgus element of the flat-foot deformity is produced at the talo-navicular joint. But it is a normal movement, in a normal joint. Toe raising, by restoring the vertical arch, automatically corrects the valgus (Figs. 9 and 10).

OPERATIVE CORRECTION

In 1931 Hoke described the operation of naviculo-cuneiform fusion as treatment for relaxed flat foot. He believed that muscles were pre-eminent in maintaining the long arch and claimed that the operation lengthened the lever through which they worked and thereby rendered them more effective. He recommended lengthening the tendo calcaneus at the same time. In 1937 Butte reported seventy-six feet operated upon, and claimed satisfactory results in half. He suggested that the operation was most successful when lateral radiographs showed a sag at the naviculo-cuneiform joint. If it is accepted that the posture of the foot depends upon the structure of the joints and the integrity of the ligaments, and if radiographs show a localised defect in the long arch at the naviculo-cuneiform joint, the logical assumption

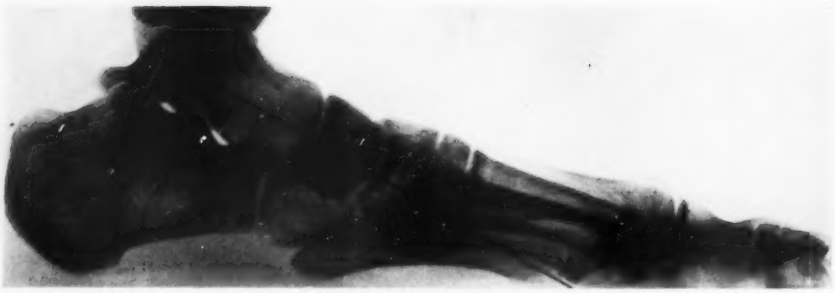

FIG. 7

FIG. 8

Naviculo-cuneiform break (Fig. 7) corrected by toe raising (Fig. 8).

FIG. 9

FIG. 10

Same foot in antero-posterior view. Automatic correction of valgus angulation at talo-navicular joint.

follows that fusion of this joint in the corrected position should restore the arch, balance the foot, and cure the deformity, without seriously impairing the mobility of the foot.

During the four-year period 1946–1949, forty-six feet in twenty-five patients, all between the ages of eleven and fourteen, have been operated upon, and the cases have been followed up for periods varying from five years to fifteen months after operation. The operation is easy but must be performed with precision. Exposure of the first cuneiform is improved by division of the broad tendon of tibialis anterior across half its width. Adjacent joint surfaces of navicular and medial cuneiform are excised. While an assistant holds the foot firmly in the corrected position a slot is cut in the navicular and cuneiform bones across the joint to receive an accurately cut cortical and cancellous graft from the upper third of tibia, which is countersunk firmly (Fig. 11). The excised joint space is packed with bone chips. Plaster is applied to hold the foot in full correction and must be carefully moulded round the first metatarsal. If the tendo calcaneus is tight the foot is put up in slight equinus. In this series the tendo calcaneus has not been lengthened. No weight bearing is permitted for three months. Walking in plaster is allowed during the fourth month.

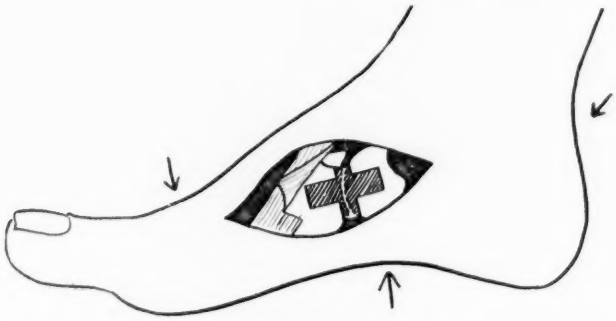

FIG. 11

Excision of joint surfaces and insertion of tibial key graft while the foot is held strongly in the corrected position.

Indications for operation—All the patients subjected to operation had previously received conservative treatment for variable periods (some for many years). Operation was recommended when growth had proceeded to a sufficient stage to permit fusion, because there was marked instability of the feet which was either causing restriction of activity or was considered likely to do so in the future. In twenty-six of the forty-six feet there was pain after long walks; twenty-four caused restricted activity at games; while in fourteen the main complaint came from the parents, who were greatly harrassed by the rapid break-down of shoes after a few weeks' wear, in spite of Thomas heels and wedges.

RESULTS

In assessing results the balance of the foot, function and mobility, relief of symptoms, and cosmetic appearance have been taken into account. Cases have been graded as excellent or good—classified together as satisfactory—and as unsatisfactory. To qualify for satisfactory assessment the relaxed foot must have good balance, function must be unrestricted, and symptoms must be completely relieved. Twenty-five of the forty-six feet have been graded as excellent, and thirteen as good. Thus thirty-eight of the forty-six (or 82 per cent) can be regarded as satisfactory. Twenty-four of these previously complained of pain in the feet, and all were completely relieved. A typical case is shown in Figures 12 to 15.

FIG. 12

FIG. 13

Case 1—Severe flat-foot deformity with pain after long walks. Conservative treatment unsuccessful. Operation at age fifteen. Figure 12—Before operation. Figure 13—Four years after operation.

FIG. 14

FIG. 15

Case 1. Figure 14—Radiograph before operation. Figure 15—Four years after operation.

Thirteen feet, although they fulfilled the necessary criteria for a satisfactory result, failed to achieve the highest grade for the following reasons. Eight were not quite completely balanced and might have been a little better had the naviculo-cuneiform angle been slightly more corrected. One deformity was slightly over-corrected and presented a trace of inversion at the heel (Figs. 16 and 17). Three had rather prominent navicular tubercles which spoilt the cosmetic appearance of a well balanced foot. In one case there was slight crepitus at the midtarsal joint but the foot was otherwise excellent. One patient developed a pseudarthrosis in one foot but after a second operation two years later gained an excellent result.

Eight feet (18 per cent) were classed as unsatisfactory. Five of these were among the first eight feet operated upon. In two cases failure was due to pseudarthrosis. Walking

FIG. 16

FIG. 17

Case 2—Severe flat-foot deformity with pain after long walks. Operation at age twelve. Figure 16—Before operation. Figure 17—Two years after operation. There is slight inversion of the right heel.

had been allowed in plasters three weeks after operation. Fusion failed and correction was lost. In five the operation failed to restore the arch. This failure was attributed to bad selection; further scrutiny of the pre-operative radiographs showed that the break was not confined to the naviculo-cuneiform joint, but that the talo-navicular joint was also involved. One patient reported five years after operation with a stiff midtarsal joint and radiological evidence of osteoarthritis. Probably the graft was inserted too deeply and had encroached on the talo-navicular joint. The failures can all be attributed to errors in technique or to faulty selection and are avoidable. Failure of fusion occurred three times in early cases before it was realised that early weight bearing must not be allowed. In one foot re-operation achieved complete success.

The tendo calcaneus—In twenty-three of the cases which proved satisfactory it was noted before operation that the tendo calcaneus was tight. The tendon was not lengthened, but at follow-up all these patients had a normal range of dorsiflexion. When the heel is habitually everted the calf muscles no longer need to extend fully and they undergo adaptive shortening. Once the arch is stabilised re-adaptation quickly occurs. Tendon lengthening is unnecessary.

Comment—The operation is not by any means a universal cure for flat foot. Selection of cases must be made with great care and depends on a reliable radiographic technique. Provided the defect is shown to be exclusively or preponderantly at the naviculo-cuneiform joint, the operation affords an excellent means of restoring a normal arch and preserving an almost fully mobile foot.

SUMMARY

1. Radiological investigation of cases of flat foot shows that they form three distinct anatomical types according to the precise level of the break in the arch.

2. When the break occurs at the naviculo-cuneiform joint alone, fusion of this joint in normal alignment should correct the deformity.

3. The results of operation on forty-six feet are analysed. Eighty-two per cent proved satisfactory. Failures are discussed and are considered avoidable by careful selection and operative technique.

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LIPOMA CAUSING A POSTERIOR INTEROSSEOUS NERVE LESION

DAVID A. RICHMOND, BURNLEY, ENGLAND

A man aged sixty-two years complained of inability to extend his left index finger and thumb. This paralysis had been progressing for about twelve weeks, and had been accompanied by pain in the upper arm radiating into the forearm. On examination, there was paralysis of the extensor muscles of the left thumb and index finger. There were no sensory changes. In the extensor muscles, just distal to their origin from the humerus, there was an ill defined intramuscular tumour.

Differential diagnosis—Since the patient was a painter, lead poisoning was considered, but was excluded. Because of the pain in the upper arm a cervical disc prolapse was suspected, and a radiograph showed marked narrowing of the disc space at the level of C.5-6. But there was no evidence that the paralysis was due to root pressure. A posterior interosseous nerve lesion seemed the correct diagnosis; the cause was assumed to be the intramuscular tumour near the extensor origin. Radiographs of the elbow showed a radiotranslucent, lobulated tumour lying lateral to the neck of the radius, and presenting the unusual appearance of an air bubble in the tissues (Fig. 1). Since the paralysis was gradually extending to involve all the finger extensors, operation was undertaken.

FIG. 1
Radiograph showing radiotranslucent area around neck of radius.

Operation—The radial nerve was exposed at the point of its division at the elbow. The tumour was found to be a lipoma lying under this point of division, in the substance of the supinator. The posterior interosseous nerve was stretched over the convexity of the tumour. The lipoma lay in contact with the periosteum covering the neck of the radius, and extended round the bone as far as its posterior aspect. It was removed without damage to the nerve.

After operation slow recovery occurred. Six months after operation the extensor digitorum was contracting against gravity, and after eleven months there was a flicker of movement in the extensor pollicis longus. The disability was slight and the patient was back at work. When seen five months later all muscles had recovered.

Comment—This case is of interest because of the seeming rarity of peripheral nerve lesions caused by lipomata. In a search of the literature the author has failed to find a report of a similar case.

HYDATIC CYSTS OF THE FEMUR

Total Removal of the Femur and Replacement by a Complete Cadaveric Femur

RAFAEL GARCIA CAPURRO and PEDRO VICTOR PEDEMONTE, MONTEVIDEO, URUGUAY

A man of forty-one complained of pain in the upper third of his left femur, radiographs of which showed extensive changes in the shaft of the femur, suggestive of hydatid cyst formation. He was referred to the British Hospital at Montevideo for treatment.

Examination—A complete study of the patient did not show evidence of hydatic cysts in any other part of the body. A biopsy was undertaken on the upper third of the left femur. On opening the fascia lata there was found a small hydatic abscess which clearly arose from the bone.

Treatment—From our previous experience the only efficacious treatment we could offer was amputation of the lower limb with disarticulation at the hip joint, which was the only method then known to prevent spread of the hydatic disease to the neighbouring bones. Wishing to avoid amputation, we considered the possibility of total excision of the bone only, and substitution of an internal prosthesis which might be either an acrylic femur or a bone taken from a corpse. One of us (P. V. P.) had previously obtained successful results from replacement of phalanges and metacarpal bones with cadaveric bones, and his experience encouraged us to attempt replacement of the entire femur. The patient was admitted to await an opportunity of obtaining a suitable femur. On August 21, 1951, the femur of a young girl, who had died a few minutes before from an accident, was removed with full aseptic precautions and stored temporarily in a refrigerator. The blood groupings were taken, and the bloods were found to be incompatible. Two hours after the death of the girl, the operation on our patient was begun.

Operation—The patient was placed on his right side. A long incision was made on the lateral aspect of the femur, from five centimetres proximal to the hip joint to five centimetres distal to the knee joint. The skin, fatty tissues, fascia lata and some lateral fibres of the quadriceps were divided, and at the upper extremity the incision was divided into two branches, to cut out the muscular insertions of the greater trochanter that were already invaded by the hydatic abscesses. The lateral aspect of the femur was exposed and dissected free throughout its length, the periosteum being left intact on the bone. When the muscular attachments on the posterior aspect of the femur were being divided two or three small hydatic cysts were seen. Nothing was put into the wound to destroy any remaining hydatic germs because we were afraid of damaging the bed in which we would lay the new bone. The new femur, three centimetres shorter, was placed in position after scarification of the periosteum. The muscles were reattached as snugly as possible to the new femur with plain catgut sutures. No attempt was made to reconstruct the ligaments of the joints. The specimen and a radiograph of it are shown in Figures 1 and 2. The joints were free of disease. The specimen is now in the Museum of the Faculty of Medicine of Uruguay in Montevideo.

Post-operative progress—The limb was immobilised in a plaster spica and antibiotics (penicillin and streptomycin) were given up to the tenth day. Progress was uneventful. The plaster was removed after four weeks, when the wound was found to be healed except in one small area where a few cubic centimetres of serous liquid were expelled. A new plaster was applied and the patient was encouraged to walk. The plaster was finally removed two months after the operation and a walking caliper fitted. A few degrees of movement were

FIG. 1

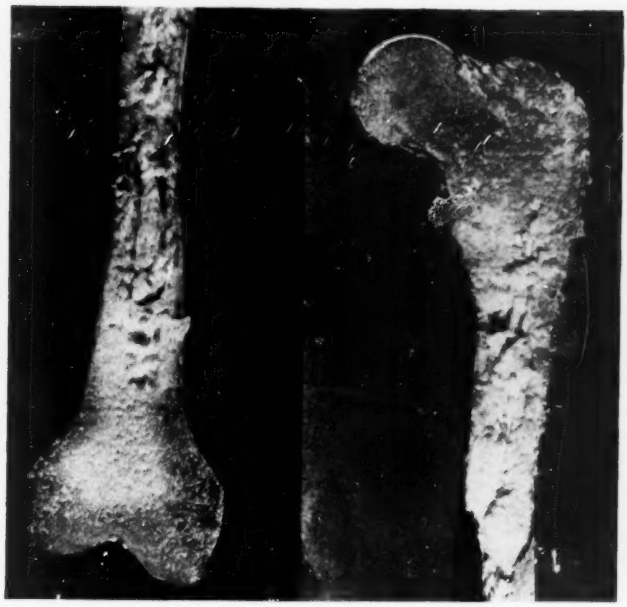

FIG. 2

Radiograph (Fig. 1) and cut sections (Fig. 2) of the excised femur.

FIG. 3

FIG. 4

Clinical photographs five months after replacement of the left femur.

FIG. 5
Radiographs of hip joint ten months after operation.

FIG. 6
Radiographs of knee joint ten months after operation.

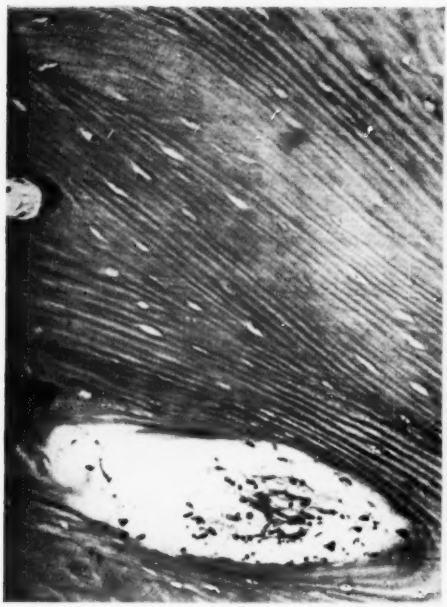

FIG. 7

FIG. 8

Figure 7—Biopsy specimen from cortical bone ten months after insertion. This area shows dead bone, but the medullary space has been reinhabited. Figure 8—In this area the medullary space has been reinhabited and in the adjacent bone some osteocytes can be seen. Elsewhere the lacunae are empty.

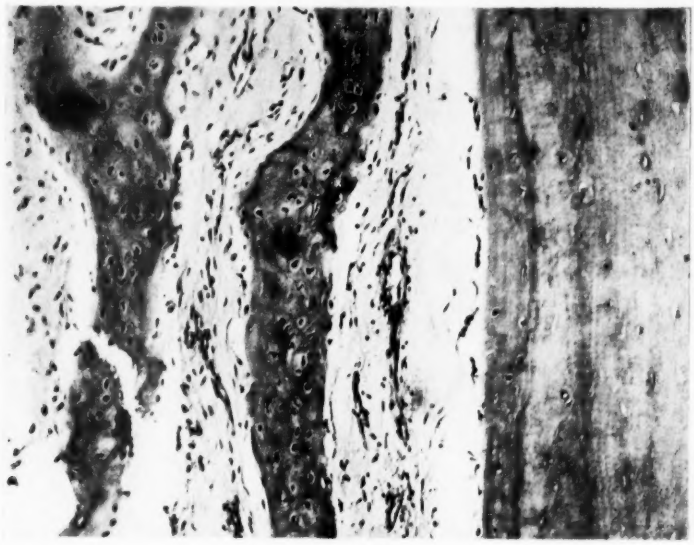

FIG. 9

Cortical bone showing, on the left, two new layers of bone formed on the subperiosteal layer. On the right the original cortex is seen; the bone cells have persisted in the superficial (subperiosteal) layers but in the deeper layers the lacunae are empty.

regained at the knee joint and slightly more at the hip, but we have not encouraged joint movements, preferring to keep the joints stiff to ensure stability (Figs. 3 and 4). Eight months after the operation a small abscess formed in the upper third of the scar. This was incised and about two cubic centimetres of pus were evacuated. Bacteriological studies showed no organisms or hydatids. The lesion healed within a few days.

Serial radiographs at monthly intervals have shown no change in the structure of the new femur; the neighbouring bones showed marked osteoporosis. The hip and knee joints are shown in Figures 5 and 6.

Ten months after the operation a biopsy of the new femur was undertaken. The tissues surrounding the bone were somewhat fibrosed. A small piece of cortical bone and some of the marrow were removed. The histological appearances are shown in Figures 7 to 9.

DISCUSSION

We appreciated that to obtain a sound knowledge of this new field of bone replacement prolonged research should be carried out and that the technique derived therefrom might be very different from that which we employed. But such studies must continue for years, and in our desire to preserve this patient's limb we felt justified in attempting the operation. Previously, we did not know the possible local or general reaction that might ensue, nor did we know how the bone would be tolerated. At the present time, ten months after the operation, the patient walks confidently, with a practically stiff knee and a slight limp which is partly accounted for by a difference of three centimetres in the length of the femora, which will be later corrected by a surgical shoe. The muscles have retained good tone, and the patient is able to raise his lower limb from the couch. There is no pain in knee or hip. So far we have regarded the bone simply as an internal prosthesis, and only time can tell us if it may be considered as something more. It is evident that an extensive field for investigation, that might possible lead to a really useful contribution to the management of bone lesions of different types, is opening up before us.

OSTEOPATHIA STRIATA—VOORHOEVE'S DISEASE

Report of a Case Presenting the Features of Osteopathia Striata and Osteopetrosis

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From the Brompton Hospital, London

Osteopathia striata is a rare developmental abnormality characterised by striation of the skeleton, especially the metaphyses of the long bones. It has been seen on only a few occasions since it was first described by Voorhoeve in 1924. The case to be reported showed well marked striation throughout the limbs and so justifies the title of the paper. The skull and ribs, however, show the appearances of osteopetrosis, and it is possible that the case may really be an atypical example of this latter disease.

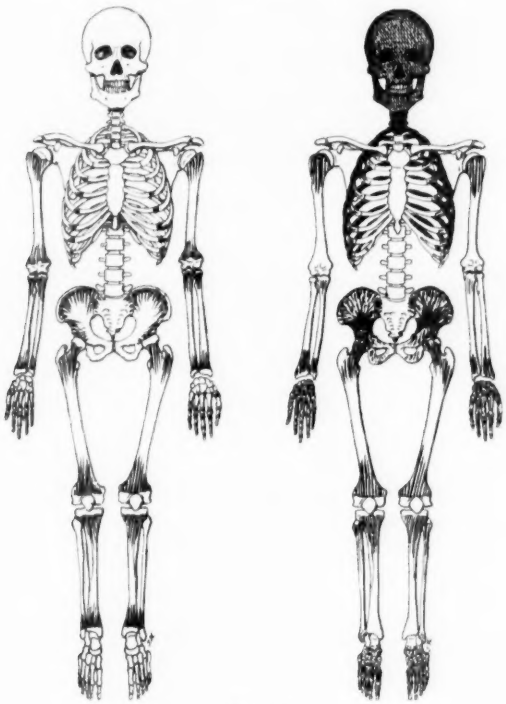

FIG. 1

On the left is shown the distribution of the changes in the long bones in Voorhoeve's case and on the right the changes throughout the skeleton in the author's case.

CASE REPORT

The patient, a rather unintelligent man of fifty-one years who had previously been healthy, developed three attacks of pneumonia within three months. Empyema complicated

the third attack and a rib resection was performed for drainage. The patient improved thereafter, but a basal shadow persisted in the radiograph and bronchoscopy showed that the

FIG. 2
Right humerus showing longitudinal striation. This was much more marked at the upper (growing) end of the bone.

FIG. 3
Tibiae and fibulae, together with the lower ends of the femora, showing longitudinal striation. This is most marked at the growing ends of the bones.

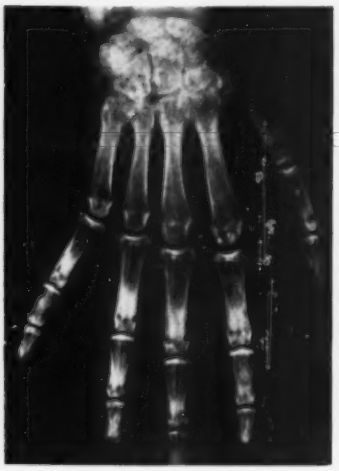

FIG. 4

FIG. 5
Figure 4—Right hand showing striation in all the metacarpals and phalanges. The carpal bones are abnormally dense and contain small translucent areas. Figure 5—Feet showing features similar to those in the hand.

left main bronchus was occluded by a mass of well differentiated squamous-celled carcinoma. Death occurred three months later but no post-mortem examination was made.

The chest radiographs had shown the ribs to be unusually dense and, to elucidate the

cause of this, radiographs were taken of the rest of the skeleton (Figs. 1 to 11). Clinical examination had revealed no abnormality apart from the chest condition. As far as could be ascertained there was no family history of bone disorder or of congenital abnormality. Radiographs of the patient's two children were normal.

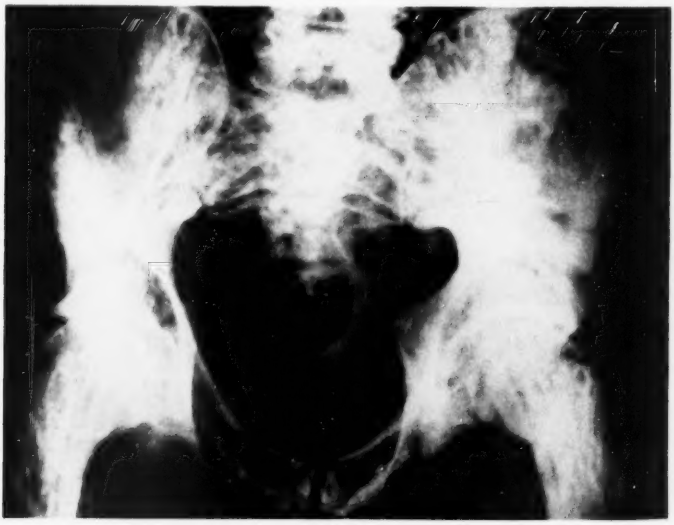

FIG. 6

Pelvis showing irregular fan-like striation in the ilium. The upper ends of the femora show a rather irregular broad striation.

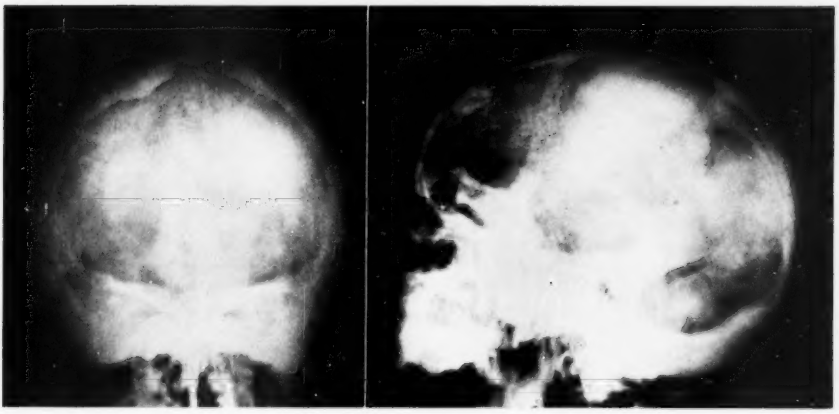

FIG. 7 FIG. 8

Figure 7—Skull showing thickening of the cranial vault and the projection of dense bone from the inner table. Figure 8—Skull showing marked thickening at the base and loss of differentiation of the vault into inner and outer tables.

Radiographic features—The main features were longitudinal striation in all the long bones, an irregular fan-like striation in the ilium and a considerable increase in density of the skull and ribs (Fig. 1). *Limbs* (Figs. 2 to 5)—All the long bones showed thin regular striae extending for a considerable distance into the metaphysis from the epiphysial line. This striation was

most marked at the growing ends of the bone. In some of the epiphyses there were a few small irregular opacities. In the carpus there were small translucent areas scattered among abnormally dense bone. *Pelvis* (Fig. 6)—In both ilia there were many elongated dense areas arranged so as to give an irregular fan-like striation. The ischium and pubis were normal. *Skull* (Figs. 7 and 8)—There was gross thickening of the cranial vault, with loss of differentiation into inner and outer tables, and in one or two areas there were projections of dense bone into the cranial cavity. The base of the skull was markedly thickened and the air sinuses, except for the frontals, were obscured. *Ribs* (Fig. 9)—All the ribs were dense and a few striae could be seen near the costochondral junctions. *Vertebrae* (Figs. 10 and 11)—There were scattered dense areas in the vertebral bodies but no differentiation into upper and lower bands as seen typically in osteopetrosis. In the lumbar vertebrae there was a suggestion of vertical striation.

Biochemical investigations—The serum calcium was 10·6 milligrams per cent, the plasma phosphorus 3·5 milligrams per cent, the serum cholesterol 235 milligrams per cent, the acid phosphatase 2·6 King units and the alkaline phosphatase 18·9 King units (two estimations) (normal 3–12 units). Plasma proteins were 4·8 grammes per cent (albumen-globulin ratio 1·2–1·0) (normal 6–8 grammes per cent). The Wassermann and Kahn reactions were negative. Blood examination showed Hb. 86 per cent, red blood corpuscles 5,300,000 per cubic millimetre, and white cells 18,200 per cubic millimetre (polymorphs 87 per cent, lymphocytes 7 per cent, eosinophils 4 per cent, basophils 1 per cent, monocytes 1 per cent). The urine was normal.

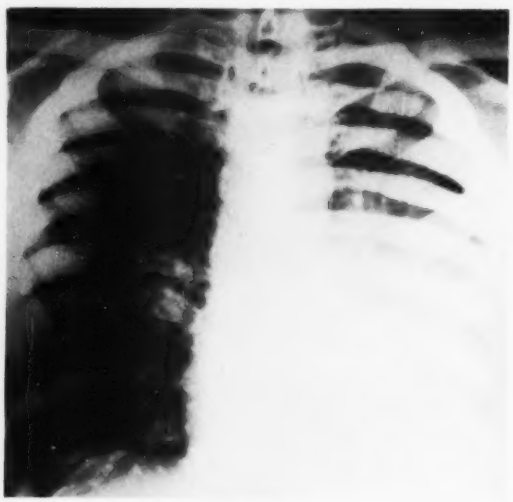

FIG. 9

Ribs showing uniform increased density and faint longitudinal striation anteriorly near the costochondral junctions.

Pathology of rib—The segment of rib which was removed was hard, so much so that there was considerable difficulty in cutting it at operation. Histological examination of the rib showed the typical structure of osteopetrosis (Figs. 12 and 13). The lamellar structure of the bone was lost due to the obliteration of the canaliculi, and the isolated lacunae appeared small and empty.

DISCUSSION

Before the nature of this case is considered it is necessary to discuss briefly the conditions of osteopoikilosis, osteopathia striata and osteopetrosis, together with their relationship to each other.

Osteopoikilosis (sometimes called Albers-Schönberg disease, though this is unfortunate in that this latter name usually refers to osteopetrosis) is characterised by the appearance of dense areas in the cancellous part of most of the bones of the skeleton, especially the long bones in the region of their epiphyses and metaphyses. These dense areas are of two types: 1) nodular lesions which are rounded or oval; and 2) striated lesions, consisting of dense lines running in the long axis of the bone for a considerable distance into the shaft. Both these forms can occur in the same patient and in the same bone.

Osteopathia striata is also characterised by striation of the long bones. The striation is thin

and well defined, lies parallel to the long axis of an otherwise normal bone, and runs for a considerable distance into the shaft. It generally begins at the epiphysial line, but it may begin near the joint surface and cross the epiphysis. Although striation is the most important feature, other changes were noted by Voorhoeve, They were: 1) small areas of translucency in the metaphysis; 2) a localised thinning of the cortex leading to a change in the shape of the metaphysis; and 3) small exostoses. In Voorhoeve's original case the ribs were of normal density and showed faint striation at their costochondral junctions. The skull was normal. *Osteopetrosis* (" marble bones " or Albers-Schönberg disease) has as its main feature a greatly increased radiographic density of one or more bones. The structure of the bone is lost but the shape, except for the development of clubbing at the ends of the long bones, remains unchanged. The density of the bone that is formed during early development is not always

FIG. 10

Cervical vertebrae, the bodies of which contain few dense areas. There is no differentiation into upper and lower bands as seen typically in osteopetrosis.

FIG. 11

Lumbar vertebrae showing irregular dense areas.

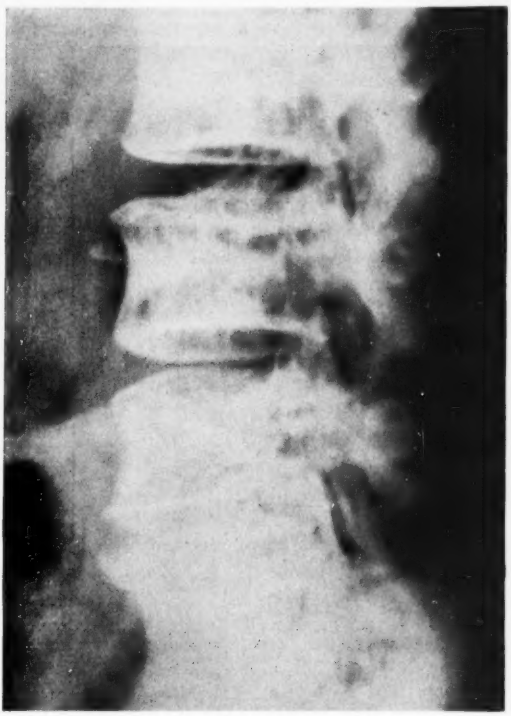

FIG. 11

the same, so that transverse bands are produced in the shaft corresponding to the changed density of the bone that is laid down. Longitudinal bands may also be formed, and typical cases of osteopetrosis have been described by McPeak (1936) and by Sear (1927) in which broad bands of dense bone extended from the epiphysis into the shaft. Furthermore, Fairbank (1948) has published a case of osteopetrosis in which the upper end of the femur showed the typical uniform increased density whereas the lower end showed longitudinal striation almost identical with that described by Voorhoeve and with that of the present case.

Previously reported cases—As far as can be ascertained only one true case of osteopathia striata has been described since Voorhoeve's original report in 1924. This case (Fairbank 1925 and 1950) was remarkable in that the changes were predominantly unilateral—in the right arm and leg, right half of the pelvis and right half of the sacrum. The striae were regular

and well defined, but by no means so numerous as in Voorhoeve's original case or in the present case. The skull was normal.

The published cases of osteopoikilosis in which striation has been an important feature have also been examined. Eleven such cases have been found, but only three show changes that are at all comparable with the changes in the limbs in the present case. The cases of Baker and Jones (1941), Jeter and McGehee (1933), Mascherpa (1931), Schéle (1921), and Von Bernuth (1932) are all examples of osteopoikilosis in which the striation is rather irregular and does not resemble that of the present case. The cases of Batten (described by Fairbank 1950) and of Uehlinger (1941) show irregular striation in conjunction with hyperostosis, and again are not really comparable. Nor is the case of Hammer (1948) in which there is a cyst-like expansion of the lower end of the ulna. The details of the remaining three cases are as follows. In Busch's (1937) case there were a few thin striae extending across the epiphysis into the shaft of the lower end of the femur and several nodular lesions in the upper end of the tibia.

FIG. 12

FIG. 13

Transverse (Fig. 12) and longitudinal (Fig. 13) sections of the rib. The lamellar structure of the bone is lost owing to the obliteration of the canaliculi, and the isolated lacunae appear small and empty (×92).

Lindbom (1942) reported striation of most of the long bones (less regular than in the present case but otherwise similar) together with a few nodular lesions, in a brother and sister aged thirteen and fifteen years respectively. Dermatofibrosis lenticularis disseminata was also present. In Windholz's (1932) case there was fine striation extending from the articular surfaces of the lower end of the femur and upper tibia across the epiphyses into their respective shafts, with many nodular lesions. Dermatofibrosis lenticularis disseminata was also present.

In none of these cases did the changes in the whole skeleton resemble those of the present case—that is, there was no appearance of osteopetrosis. The occurrence of dermatofibrosis in two of these cases is of interest; examples of the nodular type of osteopoikilosis also occurring in association with dermatofibrosis have been reported by Curth (1934) and by Von Bernuth (1932). It will be recalled that fibrosis of the bone marrow is an important change in osteopetrosis.

Author's case—It is difficult to determine whether the case reported here should be classified as a case of osteopathia striata or as an atypical example of osteopetrosis. The striation in

the long bones is identical with that described by Voorhoeve, and the rather irregular fan-like appearance in the ilium, although a little different from that in Voorhoeve's case, is quite comparable. But the dense appearance in the skull and ribs has no counterpart and is typical of osteopetrosis, a fact that is confirmed by the histological examination of the rib. Is it possible that this increased density is due to an exaggeration of the process which caused the striation in the bones of the limbs? If this is so, then the present case may represent a link between osteopathia striata and osteopetrosis, both conditions being due to the same developmental abnormality.

A possible relationship between osteopathia striata and osteopoikilosis—The suggestion that there is a relationship between the two conditions is plausible, for it is easy to postulate that osteopathia striata is a type of osteopoikilosis in which the striated form of lesion predominates to the exclusion of the nodular form. The oval nodular areas invariably lie in the long axis of the bone, and if the stimulus which leads to the formation of these nodular areas were accentuated, typical striation would be produced. Alternatively, if the tendency to produce striation were intermittently overcome, nodular areas would be formed. Voorhoeve, at a time when relatively few cases of osteopoikilosis had been described, was of the opinion that the two conditions were related, and that they were both manifestations of the same abnormal process. Other authors (Baker and Jones 1941, Erbsen 1936, Hirsch 1935, Jeter and McGehee 1933, Mascherpa 1931, Wilcox 1932, Windholz 1932) have held the same opinion, and Lindbom (1942) has published two cases under the title of "Striated Osteopoikile (Voorhoeve)." This view is not accepted by Fairbank (1950), however, who maintains that the two conditions are separate entities. It is true that the nodular areas of osteopoikilosis are prolonged in places into streaks, but these are much shorter and much less regular than the dense lines seen in osteopathia striata.

It will not be possible to give a final answer to the question of the inter-relationship of osteopoikilosis, osteopathia striata and osteopetrosis until the nature of the underlying error of development is known. It is possible that one fundamental error is common to them all. Until such a time, many cases must occur that show the features of what are at present considered to be separate disease processes.

DIFFERENTIAL DIAGNOSIS

The diagnosis of osteopathia striata rests entirely on the radiographic appearances, for the physical examination and biochemical findings are normal. The striation is characteristic and appears in bones that are normal in other respects. Osteopetrosis and osteopoikilosis are likewise entirely radiological diagnoses and their main features have been described. Other conditions to be considered when increased density or striation is a feature are as follows.

Dyschondroplasia (Ollier's disease)—In this condition the columns of unossified cartilage may give an appearance of striation at the ends of the long bones, but the striation is not so regular as in osteopathia striata. Moreover, the masses of cartilage produce a translucent appearance and may also cause broadening of the metaphysis. In the ilium an appearance slightly resembling osteopathia striata may occur, as in cases described by Bentzon (1924) and by Hunter and Wiles (1935). Voorhoeve (1924) considered that osteopathia striata represented a link between osteopoikilosis and dyschondroplasia.

Paget's disease—In Paget's disease new bone formation leads to thickening of the bones, the outlines of which are rather woolly. In the present case there is no suggestion of this, except perhaps in the vault of the skull where there is some thickening of the inner table. Paget's disease, however, usually affects the outer table first and the inner table only in the later stages.

Secondary carcinoma—Especially in the present case, an osteoblastic form of secondary carcinoma must be considered, but the widespread changes and the regularity of the striation make this unlikely. Moreover, the pathological report on the bone is conclusive.

Leri's melorheostosis—In this condition an irregular deposit of dense bone gives the appearance

of having run down the outer surface of the bone (" candle drippings ") causing thickening of the shaft. Usually only one limb is affected.

Fluorine poisoning—In fluorine poisoning the bones are normal in shape, are of increased density and show excrescences at the points where ligaments are attached, especially in the pelvis. There is a history of exposure to fluorine-containing dust, and usually the patient complains of gastro-intestinal sypmtoms (Møller 1939).

Syphilis—In syphilis there is evidence of a periostitis and the Wassermann and Kahn reactions are usually positive.

SUMMARY

1. A case is reported which shows the typical features of osteopathia striata in all the long bones and probably in the pelvis, with the features of osteopetrosis in the skull and ribs.

2. The occurrence of longitudinal striation in osteopoikilosis and osteopetrosis is described, and the possible relationship between these two diseases and osteopathia striata is discussed.

3. The differential diagnosis is indicated.

I am indebted to Mr N. R. Barrett for permission to publish this case; to Professor W. G. Barnard for the histological report on the rib; to Dr James Brailsford for helpful advice; to Dr L. G. Blair for permission to publish the radiographs; to Dr K. S. Rodan for the decalcified section of the rib; to Dr J. Kochanowski for the diagrams of the skeleton; and to the photographic department of the Institute of Diseases of the Chest for the photographs.

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CERVICAL HYPEREXTENSION INJURIES WITH PARAPLEGIA

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Paraplegia complicating hyperextension injuries of the cervical spine has occasioned much speculation as to its cause. Although Barnes (1948) has advanced a convincing and acceptable interpretation of the mechanism of hyperextension injury in arthritic spines, he was unable, either after post-mortem examinations or in experiments on cadavers, to demonstrate any gross pathology of the cord sufficient to explain the paraplegia.

Crooks and Birkett (1944) in a series of fifty-nine fractures and dislocations of the cervical spine, found that twelve occurred in pathological spines, of which ten were osteoarthritic. They considered it possible that some of these accidents were due to hyperextension injury, but were unable satisfactorily to identify these cases. In only two cases was there radiographic evidence of bone injury, and yet eight patients had complete or incomplete paraplegia, which was fatal in six. Post mortem examination in two cases revealed a torn anterior longitudinal ligament with a split disc, allowing abnormal displacement of bones, and consequent haemorrhage in the cord at the level of the lesion. They considered that cord injury was due to pressure or haemorrhage caused by traction on the cord or the nerve roots.

Barnes (1948) found six hyperextension injuries in arthritic spines, of which five were fatal. Post-mortem examination was performed in two cases and revealed rupture of the anterior longitudinal ligament with rupture or avulsion of the intervertebral disc, and an intact posterior longitudinal ligament in each case. The spinal cords were normal in appearance except for a slight constriction at the level of the injury. Barnes was unable to explain the lesion but considered that spinal concussion or traction injury at the moment of extreme hyperextension might be the causative factor.

Taylor and Blackwood (1948) described one fatal case, and suggested that in cases of paraplegia in cervical injuries with normal radiographic appearances the usual mechanism is hyperextension. Taylor (1951) has described a fatal case following hyperextension with no demonstrable skeletal or ligamentous lesion, although there was posterior softening of the cord and microscopic evidence of destruction. He advanced experimental evidence to suggest that the injury may have been caused by inward bulging of the ligamentum flavum during hyperextension.

CASE REPORT

A man aged fifty-four years was thrown over by a wave while sea-bathing, and was carried from the water completely paralysed but fully conscious. He was unable to recollect the position into which he was thrown by the wave. He was retained in a cottage hospital for two days before being transferred to the orthopaedic unit. Examination showed complete paraplegia up to the seventh cervical segment. There was a superficial abrasion on the middle of the forehead. Radiographs showed anterior marginal osteophytes on the bodies of the

FIG. 1

Radiograph of cervical spine showing osteoarthritis with fracture of marginal osteophytes.

fourth, fifth, sixth and seventh cervical vertebrae (Fig. 1). An osteophyte at the antero-inferior margin of the fourth vertebra appeared to be fractured. In the antero-posterior

FIG. 2

FIG. 3

Figure 2—Radiograph of the specimen in extension, showing abnormal separation between C.5 and C.6 bodies. Figure 3—Sagittal view of the specimen showing rupture of the anterior longitudinal ligament and splitting of the disc. The change in texture of the cord above C.7 is evident.

FIG. 4

FIG. 5

FIG. 6

The dissected cord. The anterior view (Fig. 4) and the posterior view (Fig. 5) show the anterior spinal artery only in the lower third. The sagittal section (Fig. 6) shows normal texture in the lower third of the cord, which coincides with the intact blood supply, and above this an area of liquefaction-necrosis. Degenerated cord substance has actually crumbled away from the left half of the specimen.

view there was a suggestion of an increased gap between the fifth and sixth vertebrae. A diagnosis of hyperextension injury was made. Death occurred seven days after the injury.

Post-mortem examination (with Dr I. Prinsloo)—After removal of the cervical viscera it was seen that there was a defect of the anterior longitudinal ligament between the fifth and sixth cervical vertebrae. When the head was allowed to fall back over the end of the table a gap of six millimetres opened up between these two vertebrae; on flexion of the neck this gap closed completely. There was no evidence of ante-mortem haemorrhage in this region. The affected part of the cervical spine was removed for further examination. There was a complete rupture of the anterior longitudinal ligament between the fifth and sixth vertebrae. The supraspinous and interspinous ligaments and the ligamenta flava were intact, as were the posterior intervertebral joints. Approximation of the spinous processes caused hyperextension with springing open of the gap between the fifth and sixth bodies (Fig. 2). The specimen was divided sagittally slightly to the right of the mid-line to preserve the anterior spinal artery (Fig. 3). The anterior longitudinal ligament and the intervertebral disc were seen to be ruptured but the posterior longitudinal ligament and the dura were intact. The intervertebral discs immediately above and below the level of injury were atrophied, and there was some posterior displacement of disc material causing a bulge into the vertebral canal and a " waist " in the cord at these levels. This bulging was accompanied by posterior marginal osteophytes as described by O'Connell (1951), indicating that the bulge was due to a degenerative process of some standing and not to the recent injury. The cord opposite the bodies of the lower two vertebrae was firm and appeared normal on macroscopic examination, but above this level it was soft and yellowish and appeared to be in a state of liquefaction-necrosis. The cord was dissected and the appearances are shown in Figures 4 to 6. *Anterior view* (Fig. 4)—The anterior spinal artery was identified in the lower part of the specimen and was traced over two segments to a level coinciding with the upper margin of the body of the seventh cervical vertebra. Above this level no continuity of vascular supply was seen until the top half-inch of the specimen. *Posterior view* (Fig. 5)—The posterior spinal arteries were identified in the lower part of the specimen as far up as the level coinciding with the upper border of the seventh cervical vertebra and then again over the segment coinciding with the fourth cervical vertebra. Between these two levels no continuity of vascular supply was seen. *Sagittal section* (Fig. 6)—In the lower part of the specimen the cord was firm and intact but above the level coinciding with the seventh cervical vertebra it was soft and necrotic and the left half actually crumbled away piecemeal while being stored in the preservative solution.

DISCUSSION

So far no observer has been able to offer any definite finding to explain the suppression of cord function. Crooks and Birkett (1944) suggested that the lesion was due to pressure or haemorrhage as a result of traction, but there was no visible evidence of this in our case. Birkett (1950), reviewing the subject six years later, admitted that there was no satisfactory explanation of the neurological injury but thought that intramedullary injury may be due to cord or root traction. Barnes (1948) also suggested cord traction or concussion at the moment of extreme hyperextension as the causative mechanism although he was unable to demonstrate any such forces in his cadaver experiments. Jefferson (1948) in an editorial on the problem admitted that total extinction of cord function can occur without any obvious changes being seen, but did not favour concussion of the cord as a cause for the paraplegia. Taylor (1951) is the only author so far to ascribe the cord lesion to any definite mechanism.

The findings in our case suggest that the paralysis was due to a molecular disintegration of the cord as a result of interference with its blood supply. Gray's Anatomy (1935) describes the blood supply of the spinal cord as follows: " *The anterior spinal artery* descends in a median position in or on the linea splendens and is reinforced by a succession of small spinal twigs which enter the vertebral canal through the intervertebral foramina. *The posterior spinal arteries* descend on each side as two branches, one in front of, and the other behind, the posterior roots of the spinal nerves and are reinforced by spinal twigs which enter through

the intervertebral foramina and accompany the posterior nerve root filaments." It seems reasonable to suggest, in the case reported here, that at the moment of extreme hyperextension a stretch injury of the spinal arteries resulted in an intimal tear with consequent thrombosis spreading over several segments and causing a liquefaction-necrosis of the cord in this area. Reference to Figure 3 reveals that the level of the spinal lesion coincides with the middle of the necrotic area. Had the spinal arteries been torn, evidence of subarachnoid or subpial haemorrhage would have been expected, but this is not seen. If this suggestion is valid, the pathological changes described would be found only if the patient lived long enough for them to take place. In Barnes's Case 9, that of a patient who died on the second day, no medullary changes were observed, but the photograph of the cord shows deficient posterior spinal arteries for some distance below the constriction. It is possible that if the patient had lived longer, pathological changes would have been seen. In Barnes's Case 12, that of a patient who died on the tenth day, there is no record of the appearance of the cord on section; so no inference can be drawn.

A disturbing element in this case is the discrepancy between the clinical level of the lesion and the pathological findings. Sensation was present down to and including the seventh cervical segment, and preservation of the power of forearm flexion indicated function in the fifth and sixth cervical segments (Last 1949). On the other hand the necrosis of the cord extended over the fifth, sixth and seventh cervical segments. No explanation of this phenomenon is attempted.

It is hoped that further observations will be made in similar cases and that whenever possible detailed dissection of the cord will be undertaken to establish whether pathological changes of the type described in this report are common.

SUMMARY

1. The literature on paraplegia complicating hyperextension injuries of the cervical spine is reviewed, and the lack of any definite explanation of the mode of interference with cord function is noted.

2. A case is described in which a detailed dissection of the post-mortem specimen was carried out. On the basis of the findings it is suggested that one cause of the suppression of cord function in such injuries is thrombosis of the spinal arteries and liquefaction-necrosis of the cord.

I wish to thank the Medical Superintendent of Addington Hospital for permission to report this case and Dr N. Sacks for the use of the radiographs.

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AN UNUSUAL BONE TUMOUR COMPLICATING PAGET'S DISEASE

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Malignant tumours complicating Paget's disease usually take the form of osteogenic sarcomata. In 1949 Russell reported three cases of malignant osteoclastoma complicating Paget's disease and gave a detailed description of the histology. The case reported here is that of a similar malignant osteoclastoma developing in the mandible of a man with long-standing and widespread Paget's disease. The case is also of interest in that skeletal changes suggestive of Paget's disease developed in two of the patient's offspring, as reported elsewhere in this Journal.*

CASE REPORT

A man of sixty-five years was admitted to Hill End Hospital under the care of Mr Rainsford Mowlem, complaining of a painful swelling of the left mandible. He gave a history of having suffered from Paget's disease for thirty years, the primary involvement being of the tibiae and left arm. Fourteen years previously an injury to the right temporal region had been followed by local overgrowth of bone. Six months before his admission a swelling had developed rapidly in the left mandibular area but had remained about the same size since a few days after its appearance. Recently it had become painful.

Examination at that time showed Paget's disease with a widely open bite and gross over-development in the symphysial region. The right temporal fossa was filled with new bone and at the left angle of the mandible there was a large swelling, confined mainly to the outer surface and not apparently cystic; within the mouth it was smooth and replaced the whole of the alveolus so that the wearing of a denture was impossible. Mandibular development in front of the swelling was excessive. Radiographs of the skull showed extensive Paget's disease with an area of destruction at the angle of the left mandible and expansion of the cortex of the bone (Fig. 1).

Fig. 1

Before operation. Advanced Paget's disease of skull with expanding lesion of left mandible.

Treatment—Because of the length of the history and absence of progressive enlargement of the swelling during the previous six months, a clinical diagnosis of a benign tumour was made. Operation was undertaken for relief of pain (Mr Rainsford Mowlem). An incision was made below the main part of the swelling along the body of the mandible on the left side. Anteriorly this was deepened to expose normal bone, but over the swelling itself no apparent bone layer

* Irvine, R. E. Familial Paget's Disease with Early Onset. Page 106.

remained. The facial vessels were divided and the remnants of the masseter dissected off the tumour by blunt dissection. This process was continued upwards to free the alveolar mucous membrane and, beginning anteriorly, the tumour was enucleated. It was solid but friable and left behind extensions almost in the form of loculi. Between these extensions there was a "sandy" type of osteo-fibrotic bone. This was trimmed down and the residual areas of growth were excised.

Histological examination—The tumour was composed of giant cells of osteoclast type in a cellular spindle-cell background (Fig. 2). The matrix cells varied in size and staining. There were moderate numbers of mitoses. The appearances were those of an osteoclastoma and suggested the possibility of malignant change.

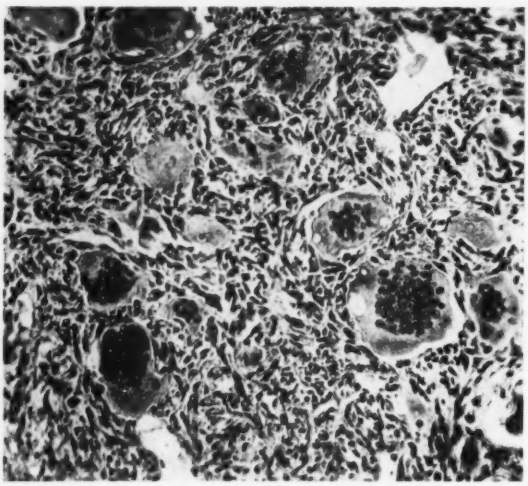

FIG. 2

Section of the tumour removed by local excision from the left mandible, showing giant cells of osteoclast type in a cellular matrix (×120).

Progress—Despite satisfactory healing of the wound considerable pain persisted. Within two weeks a further swelling appeared on the under and inner aspects of the left mandible in the region of the angle and increased rapidly in size. In view of the histological report of osteoclastoma, he was transferred to the Middlesex Hospital under the care of Professor B. W. Windeyer for radiotherapy. Examination (eight weeks after operation) showed extensive Paget's disease affecting most of the skeleton (Figs. 3 and 5). There was a large swelling of the left mandible, most marked at the angle of the jaw. Within the mouth there was a large ulcerated tumour protruding from the inner surface of the left mandible and extending to within two centimetres of the midline anteriorly. The swelling occupied most of the left side of the floor of the mouth and pushed the tongue over to the right. The tumour had extended up the ascending ramus of the mandible and was pushing the soft palate forwards and downwards. Radiographically, there was extensive erosion of the left mandible (Fig. 6). There was no evidence of secondary deposits in the chest. *Investigations*—Blood count was normal; acid phosphatase was 3·7 units, alkaline phosphatase 57·3 units, and 17-ketosteroids were 14·5 milligrams per 24 hours. *Effects of radiotherapy and further progress*—The tumour was treated by teleradium using a five-field technique, a central tumour dose of 4,100r. being delivered in twenty-three treatments over a period of thirty days. The tumour decreased in size over the next few weeks and its centre became necrotic. Large pieces of slough and necrotic bone were removed until the cavity was clean and the edges well defined. A radiograph of the mandible two weeks after the completion of treatment showed considerable ossification in the tumour (Fig. 7). This had occurred earlier than was to be expected after radiotherapy to an osteoclastoma. Nevertheless the radiographic appearances were unlike those of sarcoma and clinically the tumour appeared to be healing. Four weeks later, however, a recurrence was noticed at the anterior end of the healing lesion and this spread rapidly, involving the whole of the left mandible and infiltrating the soft tissues of the neck (Figs. 4 and 8). Despite palliative x-ray therapy his condition deteriorated rapidly and he died six weeks later (six months after local excision of the tumour and three months after teleradium therapy).

FIG. 3

FIG. 4

Figure 3—Photograph of patient two months after operation. The tumour of the mandible, removed by local excision, has recurred. Note extensive deformities. Figure 4—Despite early reossification after irradiation, the tumour rapidly recurred and spread to involve the whole mandible.

FIG. 5

Pelvis showing advanced changes typical of Paget's disease.

FIG. 6

FIG. 7

Figure 6—Radiograph of mandible immediately before irradiation. Figure 7—Two weeks after irradiation. Note reossification.

FIG. 8

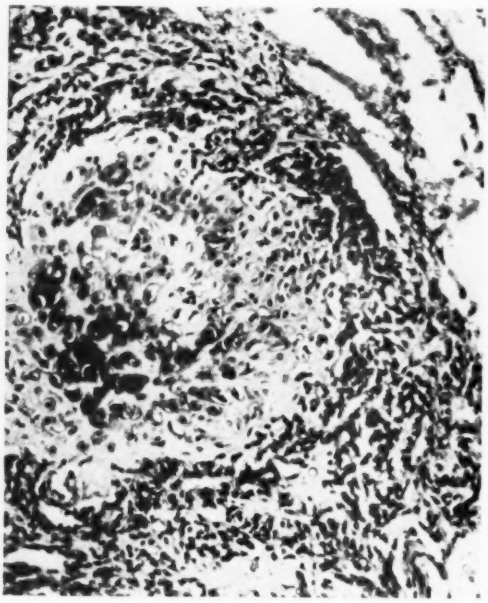

FIG. 9

Figure 8—Eight weeks after irradiation. Pathological fracture with absorption of all new bone. Figure 9—Section of the lung metastasis found at necropsy. The tumour is a chondrosarcoma and is similar to the sections of growth in the jaw taken after death (×100).

Necropsy—All bones examined showed evidence of Paget's disease. The skull measured 24½ inches in circumference. A large swelling was present in the mandible on the left side. The mandible was fractured and the bone destroyed, over a length of 3½ inches, by a soft white tumour which was also invading the alveolar margin and left side of the tongue. There was a small tumour in the right upper lobe of the lung which had the consistency and appearance of cartilage on section. Histological examination of the mandible showed chondrosarcoma, no osteoclastomatous areas being found. The lung metastases were similar in appearance (Fig. 9).

COMMENT

Since Russell (1949) drew attention to the occurrence of malignant osteoclastoma in Paget's disease no essentially similar case can be found reported in the literature. Hilton (1950) reported two cases of osteoclastoma associated with generalised bone disease, both of which failed to respond to irradiation. One of these occurred in the skull of a man with radiographic evidence of Paget's disease in the skull and pelvis. But both were histologically benign giant-cell tumours with no evidence of malignancy.

The case presented here has been reported in detail because the tumour followed an unusual course and appeared, in the first histological sections, to resemble those reported by Russell. Re-examination of the first sections has allowed no alternative histological diagnosis to that of malignant osteoclastoma. The six months' history of the tumour, without change in size or symptoms, suggested at first that it was benign. Transition from benign to malignant osteoclastoma was possibly taking place at about the time of the operation. Certainly the rapid recurrence after operation suggested a malignant tumour, and the early clinical response to radiotherapy, with evidence of rapid reossification, was most unusual for a benign osteoclastoma, initial further decalcification being the typical response. Russell's patients were not treated by irradiation and so comparison cannot be made, but the tumours reported by Hilton showed not even a temporary response to radiotherapy.

SUMMARY

An unusual bone tumour complicating Paget's disease of the mandible is described. At the time of local excision the histological appearances were those of a malignant osteoclastoma, but the tumour rapidly recurred as a chondrosarcoma, which spread locally and by metastasis, and caused death within six months.

I have pleasure in recording my thanks to Professor B. W. Windeyer and Mr Rainsford Mowlem for permission to publish this case. Dr A. C. Thackray reported on the histology and produced the photomicrographs. The clinical and radiographic photographs were taken by Mr M. Turney in the Middlesex Hospital Photographic Department.

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FAMILIAL PAGET'S DISEASE WITH EARLY ONSET

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In 1889 Paget wrote of osteitis deformans: "I have tried in vain to trace any inherited tendency to the disease. I have not found it twice in the same family." Nevertheless it is now accepted that Paget's disease may run in families, though uncommonly. The family with Paget's disease reported here consists of a father and two daughters. The father's case is of interest because of the rare type of malignant change which led to his death, and the affection in the two daughters is notable for the unusually early onset at eighteen years. There are three other siblings, two brothers and a sister, who are all in the fourth decade of life. None presents any clinical abnormality and radiographic examination of their skulls and pelves showed no skeletal changes.

CASE REPORTS

Case 1—The father of the family suffered from Paget's disease from about the age of thirty-five. The disease was noticed first in the right tibia, but later affected almost the entire skeleton, including the skull and jaws. The patient died at the age of sixty-five from malignant changes in the mandible. A detailed account of this case with illustrative radiographs is given elsewhere in this issue by Cones.*

Case 2—The eldest daughter of the patient described in Case 1 is now aged forty. At the age of eighteen years she noticed a painless swelling in the roof of the mouth, for which she consulted a dental surgeon. The swelling has not changed in the twenty-two years since its onset. Recent examination revealed a bony swelling of the left side of the hard palate and of the alveolar process of the maxilla, more marked on the left but extending across the mid-line (Fig. 1). The rest of the skeleton was clinically normal. There was no pigmentation of the skin.

Radiographic examination confirmed the bony thickening of the palatal and alveolar processes of the maxilla. There was alteration of bone structure, the changes being mainly sclerotic and hyperostotic (Fig. 2). In addition there was a large area of osteoporosis circumscripta, mainly in the left frontal region of the skull (Fig. 3). Serial radiographs have shown an extension of this lesion during the last two years but there are not as yet any sclerotic changes in it. The rest of the skeleton has remained radiographically normal except for the pelvis, which shows thickening and increased density above the right acetabulum, with coarsening of the trabecular pattern in the right ischio-pubic ramus, typical of Paget's disease (Fig. 4). *Biochemical investigations* showed a slightly raised serum alkaline phosphatase of 17·2 King Armstrong units. The serum calcium and phosphorus were normal. The patient has three sons aged twelve, ten and seven years who present no abnormalities of the skeleton.

Case 3—The youngest daughter of the family is aged thirty-two. When she was eighteen she first noticed a painless swelling of the right lower jaw. This gradually increased in size until by the age of twenty-six years the whole lower jaw was thickened and the left upper jaw was beginning to enlarge as well. Examination at that time (1945) revealed a thickening of the whole mandible, especially on the right, and of the alveolar process of the left maxilla (Fig. 5). Distended veins were visible in the skin beneath the chin. There was no pigmentation of the skin. *Radiographs* showed that the whole mandible was affected by changes of a hyperostotic and porotic type with occasional patches of sclerosis (Fig. 7). Similar changes were present in the left maxilla (Fig. 8). In the right cranial vault there was an area of osteoporosis about an inch in diameter. The rest of the skeleton was normal. *Biochemical investigations*—The serum calcium and phosphorus were within normal limits but the alkaline phosphatase was raised to 45 King Armstrong units.

Treatment—In 1946, after preliminary radiotherapy, a cosmetic operation was performed by Professor Rushton and Sir Harold Gillies, parts of the maxilla and mandible being sliced off to restore a normal contour. Marked improvement was secured (Fig. 6).

Histological examination—The operation enabled fragments of bone to be examined microscopically. Sections from the maxilla (Fig. 11) and mandible (Fig. 12) showed absorption of cortical bone by numerous osteoclasts and its replacement by fine connective tissue composed

* D. M. T. Cones: An Unusual Bone Tumour Complicating Paget's Disease, page 101.

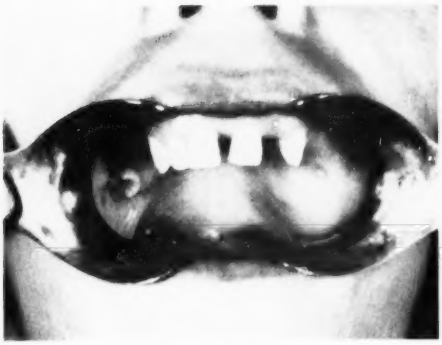

FIG. 1

Case 2—Showing the swelling of the hard palate on the left and the thickening of the alveolar process of the maxilla.

FIG. 2

Case 2—Radiograph of palate and alveolar process showing altered bone structure with hyperostosis and sclerosis.

FIG. 3

Case 2—Lateral view of skull showing osteoporosis circumscripta extending backwards from the frontal region.

FIG. 3

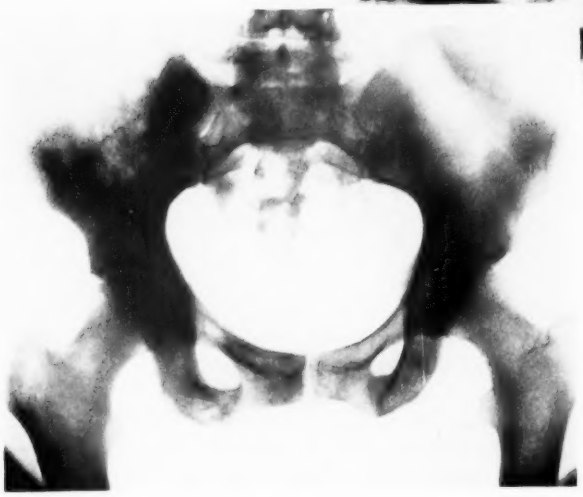

FIG. 4

Case 2—Sclerosis of right ilium and thickening of right ischio-pubic ramus with coarsening of the trabecular pattern. Note small area of osteoporosis in the right superior pubic ramus.

of spindle cells and stellate cells. Embedded in this fibrous tissue were innumerable small bone nodules of inactive appearance (Fig. 13). Figure 11 shows the formation of new osteoid trabeculae. Evidence of past bone absorption and replacement was seen in the mosaic markings shown in Figure 12. The histological picture was one of destruction of bone and its replacement by fibrous marrow with some evidence of repair and new bone formation. These appearances would do equally well for fibrous dysplasia or for Paget's disease.

Progress—Observation over six years has revealed little change in the jaws. On two occasions a regular evening temperature of 99 degrees Fahrenheit has been noted. The radiographic changes in the jaws have not altered, but the area of osteoporosis circumscripta in the skull has extended to involve large parts of the right parietal, occipital and frontal bones, and a new separate area of osteoporosis circumscripta has appeared in left frontal bone (Figs. 9 and 10). The rest of the skeleton has remained radiographically normal. The alkaline phosphatase has remained high (45–50 units). A calcium balance test carried out in 1950 showed a slight negative balance. No other biochemical changes have been observed.

This patient has two sons aged eight and five. Both are healthy and radiographic examination of the entire skeleton revealed no abnormality in either of them.

FIG. 5

Case 3—Aged twenty-six. Enlargement of the right lower jaw and some fullness of the face on the left due to enlargement of the maxilla.

FIG. 6

Case 3—Aged thirty-one. Five years after operation, showing the improved facial appearance.

DISCUSSION

The diagnosis in the case of the father was not in doubt, but in the two daughters it was not possible at first to make a firm distinction between fibrous dysplasia and Paget's disease. The younger sister, described in Case 3, came under observation before the other members of the family, and before the osteoporosis in the cranial vault had become large enough to suggest Paget's disease. The age of onset at eighteen, the involvement of the jaws, and the radiographic appearances in the mandible all pointed to a diagnosis of fibrous dysplasia. The histological picture showed nothing that would conflict with this diagnosis, and in fact the case was reported by Rushton (1947) as one of regional osteitis fibrosa, a term which is now regarded as synonymous with the milder forms of fibrous dysplasia of bone. When it became clear that the patient was developing classical osteoporosis circumscripta the

possibility of Paget's disease became more likely, despite the youth of the patient. But it was not until changes strongly suggestive of Paget's disease were found in the pelvis in Case 2 that the diagnosis became reasonably certain. These changes were not observed until twenty-one years after the original manifestations in the maxilla. The similarity

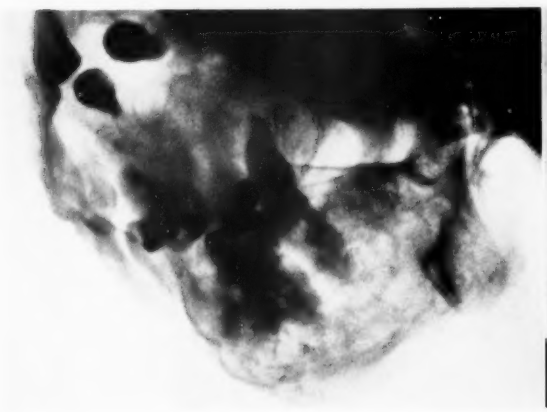

FIG. 7

FIG. 8

Case 3. Figure 7—Mandible showing marked widening with porotic and hyperostotic changes. Figure 8—Showing thickening of the left maxilla.

FIG. 9

FIG. 10

Postero-anterior and lateral radiographs of skull to show the extensive osteoporosis circumscripta.

between the skeletal changes in the two sisters is so close as to make it highly probable that they both suffer from the same condition, and it now seems justifiable to regard the lesions as examples of familial Paget's disease.

Since the papers of Sosman (1927) and of Kasabach and Gutman (1937), the close

association of osteoporosis circumscripta with Paget's disease has been generally recognised. Indeed many authorities, such as Hunter and Jupe (1950), regard osteoporosis circumscripta as a specific manifestation of Paget's disease. Others, including Snapper (1949), regard it as a localised circulatory disturbance similar to the haemorrhagic infarction of the skull described

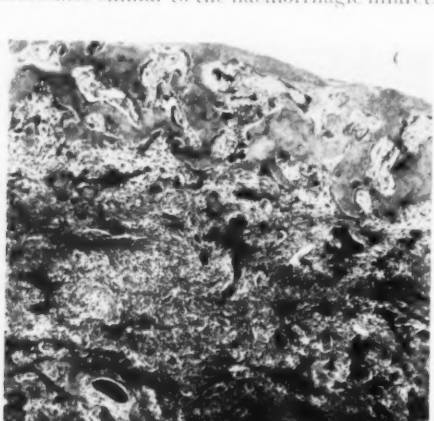

FIG. 11

Section of maxilla showing fibrous marrow containing bone nodules, and new osteoid trabeculae. The cortex (top) is being absorbed by osteoclasts (H. and E. × 33).

FIG. 12

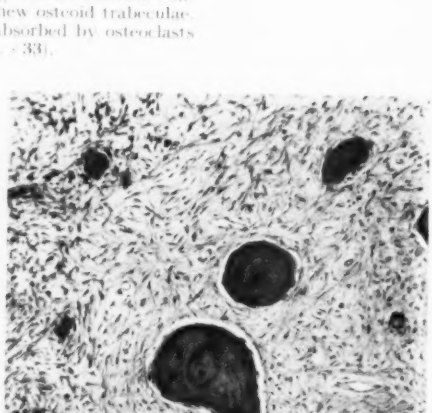

FIG. 13

Figure 12—Section of mandible. The cortex is seen with fibrous marrow below it. There are numerous giant-cell osteoclasts. Mosaic markings reveal evidence of past bone absorption and replacement (H. and E. × 63). Figure 13—Mandible. Spindle and stellate-celled area containing inactive bone nodules (H. and E. × 63).

by Schmorl (1932), and stress that although it is commonest in Paget's disease it is also found in other bone dysplasiæ, particularly those causing proliferation of the maxilla, and also in hyperparathyroidism. This view seems to rest largely on a paper by Windholz (1945), who described three cases of osteoporosis circumscripta; in two it was associated with

enlargement of the maxilla, and he considered Paget's disease to be excluded in the one on histological, and in the other on radiological, grounds. The radiographic and histological changes of Paget's disease of the jaw, however, are not always pathognomonic and it is difficult to be certain that this diagnosis is really excluded in these two cases. Windholz's third case was one of hyperparathyroidism which, however, had many anomalous features and was not helped by parathyroidectomy. Snapper (1949) mentioned three cases of hyperparathyroidism with osteoporosis circumscripta but gave no details. Albright and Reifenstein (1948) stated that Paget's disease and hyperparathyroidism may occasionally occur together in the same patient. It thus seems doubtful whether osteoporosis circumscripta is due to any cause other than Paget's disease. Sosman (1927) was probably right when he considered that osteoporosis circumscripta represented the absorptive or destructive phase of Paget's disease with the productive phase held in abeyance. Reifenstein and Albright (1944) have supported this view, suggesting that Paget's disease always begins with an osteolytic phase. In most parts of the body the normal strains and stresses of the skeleton provoke an almost simultaneous process of repair. In the calvarium, however, no such strains exist and, therefore, the phase of repair may be indefinitely delayed.

It is accepted that Paget's disease may exceptionally start in the twenties. Brailsford, for example, quotes the case of a patient aged twenty-seven. There are reports in the literature in which it is claimed that Paget's disease began below twenty, and even as early as eight years (Da Costa *et al.* 1915, Hummel 1934). Some of these cases are undoubtedly examples of polyostotic fibrous dysplasia. Thus the two boys of eight and eleven described by Hummel as suffering from juvenile Paget's disease had, in addition to their bone dysplasia, widespread café-au-lait pigmentation of the skin, a feature noted as characteristic by Albright *et al.* (1937), who accepted these two cases as examples of polyostotic fibrous dysplasia. Other cases of Paget's disease occurring below the age of twenty include that of Elsner (1910), in which skeletal changes were observed at the age of twelve, and that of Jones (1912), whose patient first had bone changes at sixteen. It is difficult and probably profitless to discuss from this distance whether these were all genuine cases of Paget's disease or examples of fibrous dysplasia.

The precise incidence of familial Paget's disease is not easy to assess. Elmslie reviewed the ninety cases recorded up to 1908 and found seven with a family history. In 1915, when the literature included over two hundred cases, Da Costa and his colleagues estimated the familial incidence at 7 per cent. Gutman and Kasabach (1936) reported four cases of familial Paget's disease in a personal series of 104 cases. Koller (1946) was able to find only twenty-seven affected families in the literature and yet he estimated the incidence of Paget's disease at 1 in 7,700 of the population of Zurich over the age of thirty. This confirms the general impression that Paget's disease is common when it is looked for, but it implies that the familial incidence is much lower than earlier work would suggest. Koller also showed that the occurrence of Paget's disease in members of the same family is due to more than chance.

Familial osteoporosis circumscripta is much rarer. I have only been able to find one example in the literature. Kasabach and Gutman (1937) described two brothers of thirty and thirty-one with widespread Paget's disease and osteoporosis circumscripta. The elder brother died at the age of thirty-one from osteogenic sarcoma of the skull.

SUMMARY

1. A father and two daughters suffering from Paget's disease are described.

2. The father's case is of special interest because he developed a malignant osteoclastoma of the mandible.

3. In the two daughters the condition was notable for the fact that in each case it began at the age of eighteen in the jaws, and led to the development of osteoporosis circumscripta of the skull.

4. The relationship between Paget's disease and osteoporosis circumscripta, and the age incidence and familial incidence of Paget's disease, are discussed.

I am grateful to Dr W. N. Mann for permission to report Cases 2 and 3, and to Professor M. A. Rushton for much kindness and help in the preparation of this article, and for permission to reproduce Figures 5 and 6. The photomicrographs were kindly provided by Mr J. E. Hutchinson. The photographs were taken by the Department of Medical Illustration, Guy's Hospital.

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THE EFFECT OF DENERVATION ON THE REGENERATION OF SKELETAL MUSCLE AFTER INJURY

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In 1865 Waldeyer pointed out that regeneration of skeletal muscle can occur after injury. Since then, others have shown that muscle regeneration may follow various types of damage including trauma (Weber 1867, Neumann 1868), ischaemia (Clark and Blomfield 1945), and toxic degeneration (Hoffman 1867, Forbus 1926). More recently the details of the histological processes involved have been described by Clark (1946).

Although it has been established that some degree of muscle repair can take place in the complete absence of innervation, as in the case of transplanted muscle tissue (Jores 1909, Clark 1946), the present investigation was undertaken to compare the histological processes and end-result of regeneration of completely denervated muscle with the corresponding findings in innervated muscle.

It is of some clinical importance to know the response of denervated muscle to injury. In some types of peripheral nerve injury, and in other lesions affecting the lower motor neuron, muscle may be denervated for long periods. Can it be expected that the denervated muscle will show an unusual response to trauma? The delicacy with which denervated muscle has been treated in the past seems to be based on a vague assumption that it is either fragile or likely to respond abnormally to damage. The present experiments were carried out to determine how far that assumption is justified.

METHOD

The rat was chosen as a convenient experimental animal. To allow comparison between different lesions, a standard muscle crush, by the technique of Clark, was employed. Under anaesthesia, the whole breadth of the muscle was crushed transversely with smooth-bladed artery forceps, producing a band of damage three millimetres wide. Histological study shows that this injury produces complete necrosis and fragmentation of muscle fibres, but that retraction of the adjacent undamaged muscle is prevented by the connective tissue stroma that remains in the crushed area. The gastrocnemius muscle was used in preference to the gracilis chosen by Clark because the small bulk of the gracilis made its identification difficult after prolonged denervation. In each experimental animal the gastrocnemius of one limb was denervated by division of the sciatic nerve in the thigh. One centimetre of nerve was excised to prevent, so far as possible, regeneration during the experiment. Three weeks later the gastrocnemius in each limb was crushed in its lowest third. Animals were killed at intervals from two hours to thirty-two weeks after injury, and the crushed muscles were examined histologically. In each animal the normally innervated muscle provided a control for comparison with the denervated one. In all, eighty-six injured muscles were examined.

The muscles were fixed in Helly's fluid, and sections were stained with haematoxylin and eosin, and by the tartrazine and lissamine fast red technique (Lendrum 1947). A few of the normally innervated muscles were fixed in 10 per cent formol-saline so that sections could also be stained to show nerve fibres and myelin sheaths.

INJURY OF NORMAL MUSCLE

Regeneration of normal muscle—Necrosis of muscle fibres and the development of granulation tissue are the earliest findings, although as early as the fourth day after injury

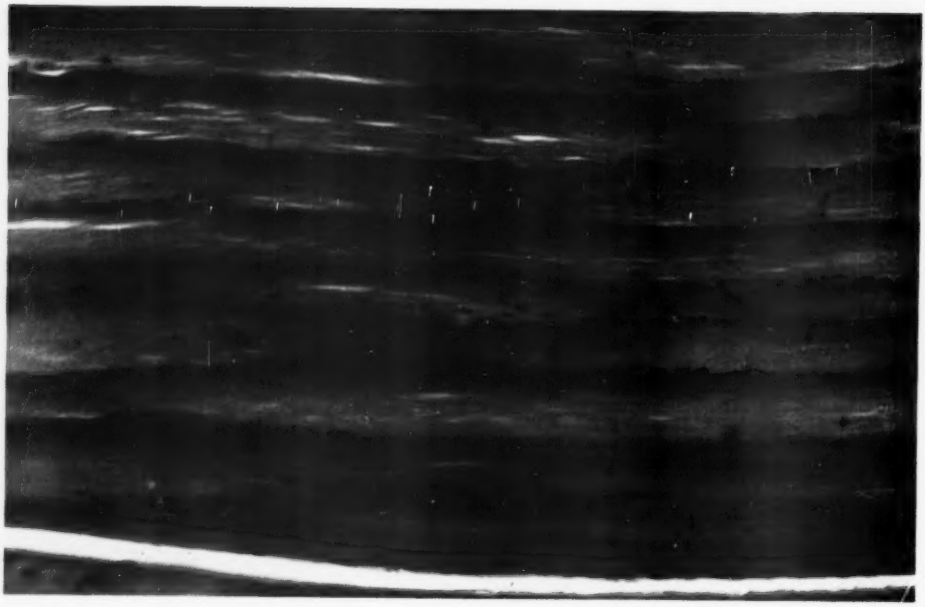

FIG. 1
Histological appearance of normal rat muscle (gastrocnemius) ($\times 220$).

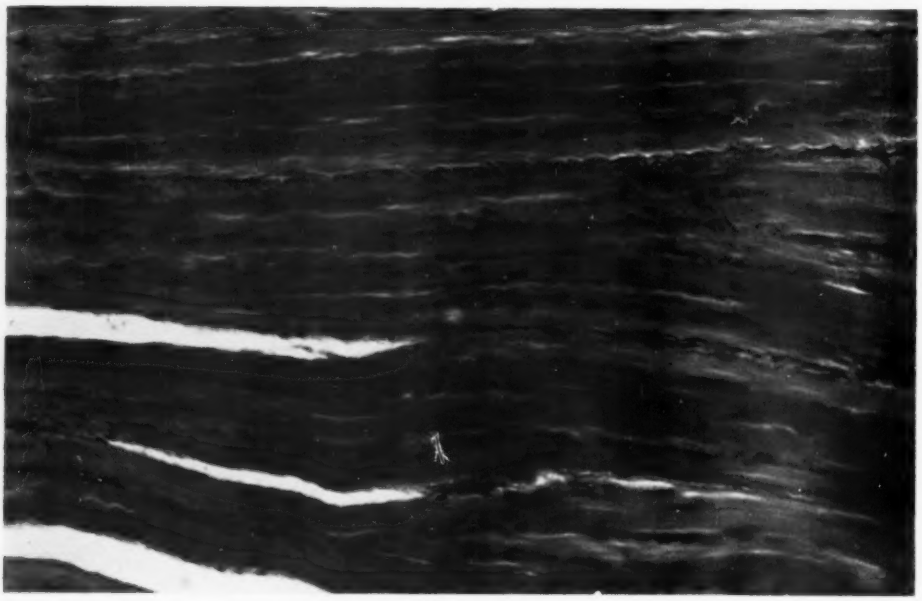

FIG. 2
Histological appearance of gastrocnemius muscle three weeks after section of sciatic nerve ($\times 220$).

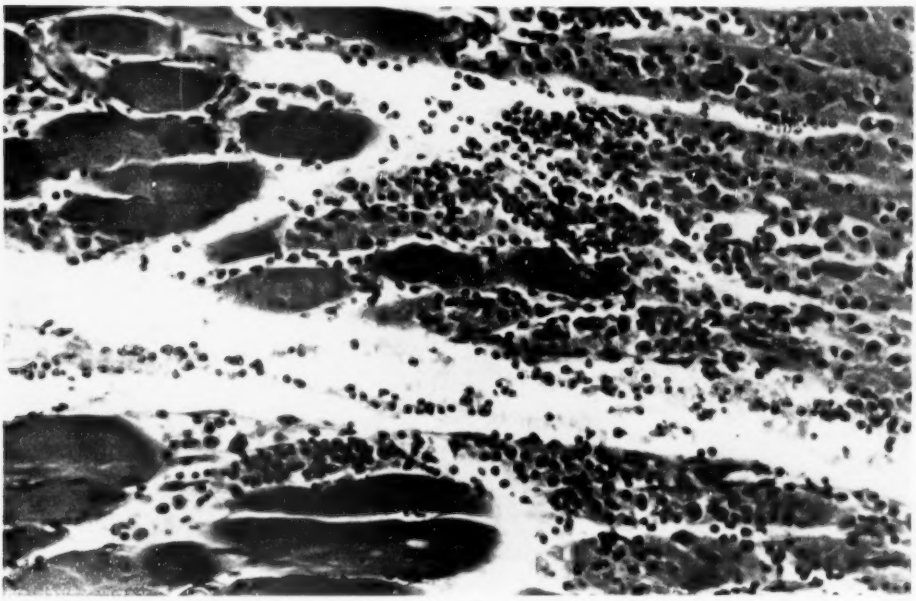

FIG. 3

Normal muscle two days after crush. In the crushed area sarcolemmal tubes are occupied by necrotic muscle fibres and numerous phagocytic cells are present (× 230).

FIG. 4

Denervated muscle two days after crush. A similar field to Figure 3, but showing almost complete phagocytosis of the necrotic muscle fibres (× 230).

regenerating muscle fibres grow into the area of damage. When the area of damage is small, as in the present experiments, the regenerating fibres can completely repair the gap, fibrous granulation tissue disappearing in from two to five weeks. After this time the site of damage is indicated only by the irregular arrangement of the muscle fibres crossing the former gap. The following is a more detailed account of the progress of muscle repair as it was seen in the specimens of normal muscle.

Immediate response—Sections of muscles removed two hours after the crush show complete interruption of all muscle fibres, the two parts being united only by connective tissue. Haemorrhage has occurred in the crushed region, and muscle fibres here are necrotic. No other significant abnormality is found.

Two days after the injury the zone of necrosis is clearly demarcated. Active phagocytosis of the necrotic fibres is well advanced, and these have become separated from the adjacent normal muscle (Fig. 3). No regeneration of muscle fibres is seen. The central part of the crushed area is occupied by necrotic muscle fibres and blood-clot, and polymorphonuclear leucocytes are conspicuous between the muscle fibres and around small blood vessels. Mononuclear inflammatory cells, including lymphocytes and macrophages, are also present. At the periphery of the crushed area other changes are found. Some empty sarcolemmal tubes are seen, where the muscle fibres have been phagocytosed by polymorphs and macrophages. At the margin of the crush vascular granulation tissue is developing, and there is some proliferation of fibroblasts between the muscle fibres, with numerous mitoses among the nuclei of these cells.

Four days—By the fourth day, specific muscle regeneration has become conspicuous. The muscle fibres at the margin of the area of damage send out slender strap-like protrusions across it (Fig. 5). These new fibres are more basophilic than normal muscle; they show longitudinal myofibrils but no cross-striation at this stage. Their numerous nuclei are frequently arranged close together in a longitudinal string. Mitoses are not seen in the regenerating muscle fibres, although they are present in the fibroblastic tissue between them.

The necrotic muscle fibres have now almost all been removed. Numerous inflammatory cells are present, and there is conspicuous fibroblastic proliferation, not only in the crushed area, but between intact muscle fibres at the margin. The central part of the crush consists of vascular granulation tissue.

It has now become apparent that the degree of damage is not the same at all points in the crushed area. In some regions the crushed sarcolemmal tubes remain more or less in continuity, while in others they are completely destroyed by the injury. The behaviour of regenerating muscle fibres appears to be governed by the state of the sarcolemmal tubes. Where a tube is present the fibre is guided across the crushed area along its original path, and if the tube extends without interruption across the zone of damage the regenerating fibres may have bridged this gap completely by four days. In other areas, where sarcolemmal tubes have been destroyed, the regenerating fibres grow irregularly into fibrous granulation tissue, and have covered considerably less distance than those growing within sarcolemmal tubes.

One week—At one week there is further outgrowth of new strap-like fibres, and more of them have bridged the crushed area. At this stage regenerated fibres may show cross-striation as well as longitudinal fibrillation, and show some increase in diameter. Some of the new fibres, particularly at the margins of the crush, appear surprisingly mature. Fibroblastic proliferation is conspicuous and in areas where sarcolemmal tubes are absent may be so extensive as to obscure scattered slender muscle fibres (Fig. 7), especially when the plane of section does not allow their continuity with normal muscle fibres to be traced. The new muscle fibres growing into granulation tissue possess, as yet, no sarcolemmal sheaths, and lie free in the tissue spaces; they frequently show bulbous, club-like terminal enlargements, which are most noticeable in areas where the fibres appear to meet most resistance from the

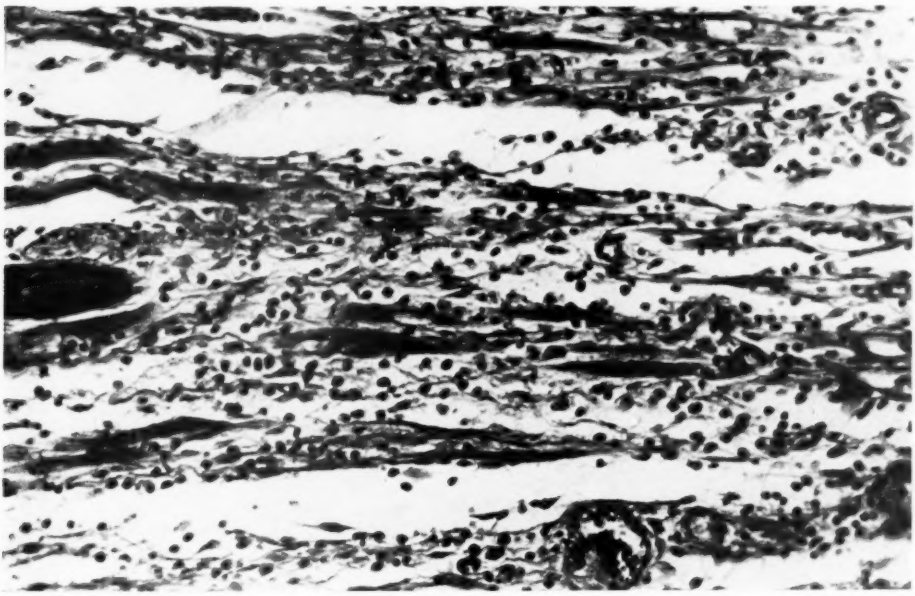

FIG. 5

Normal muscle four days after crush. Newly developed strap-like fibres streaming into the crushed area. Here regeneration is occurring in an area of intact sarcolemmal tubes (×210).

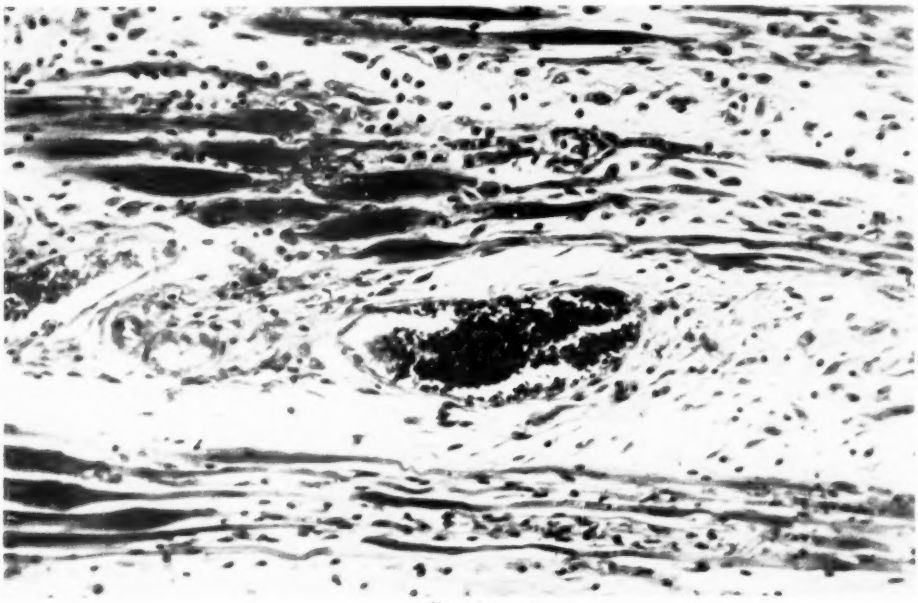

FIG. 6

Denervated muscle four days after crush. A field from the margin of the crush, showing the continuity between the narrow regenerated fibres and the thicker undamaged fibres. Here regeneration is occurring in an area of intact sarcolemmal tubes (×210).

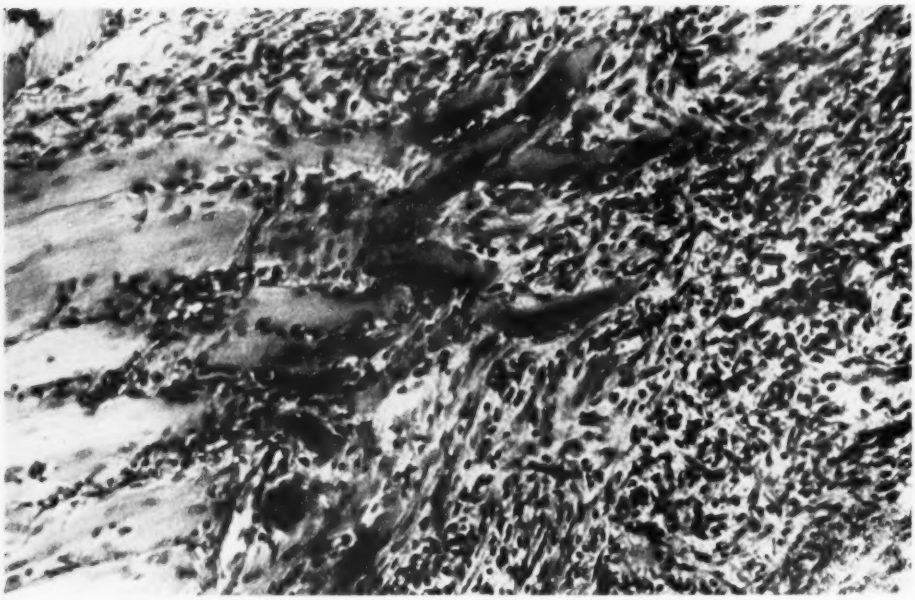

FIG. 7

Normal muscle one week after crush. Regenerating muscle fibres extending into granulation tissue, and showing multi-nucleated terminal enlargements (× 210).

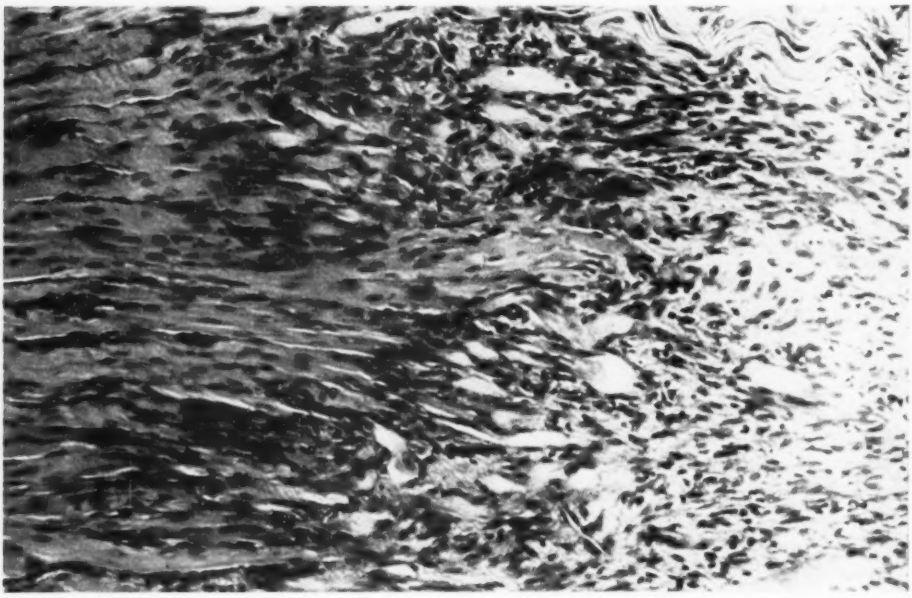

FIG. 8

Denervated muscle, one week after crush. Regenerating fibres extending into granulation tissue (× 210).

FIG. 9

Normal muscle two weeks after crush. Numerous strap-like fibres extend into the crushed area, and proliferating fibroblasts are present between them (× 190).

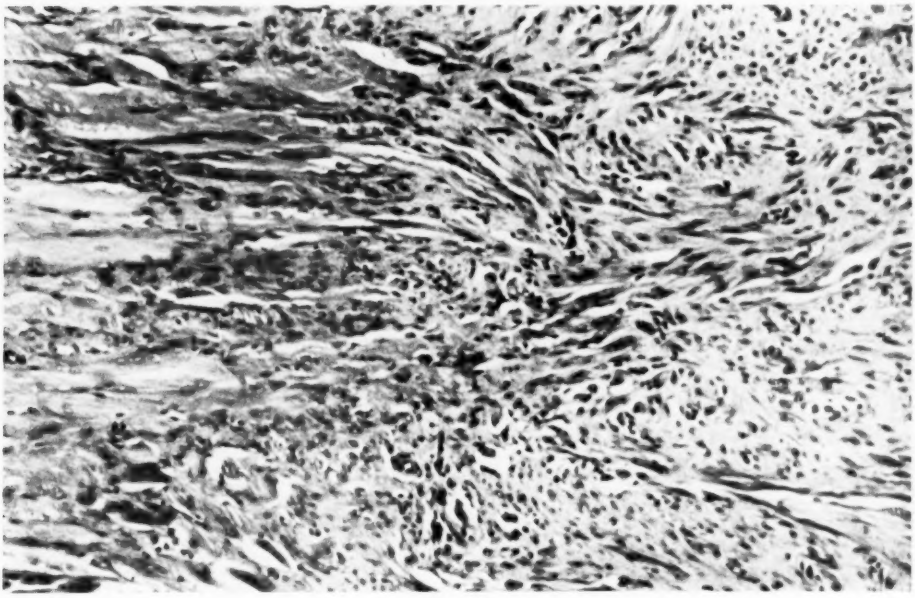

FIG. 10

Denervated muscle, two weeks after crush. Again regenerating muscle fibres and proliferating fibroblasts are seen (× 190).

FIG. 11

Normal muscle three weeks after crush (× 190).

FIG. 12

Denervated muscle three weeks after crush. In this, as in Figure 11, the area of the crush is occupied by an interlacing network of regenerated fibres (× 190).

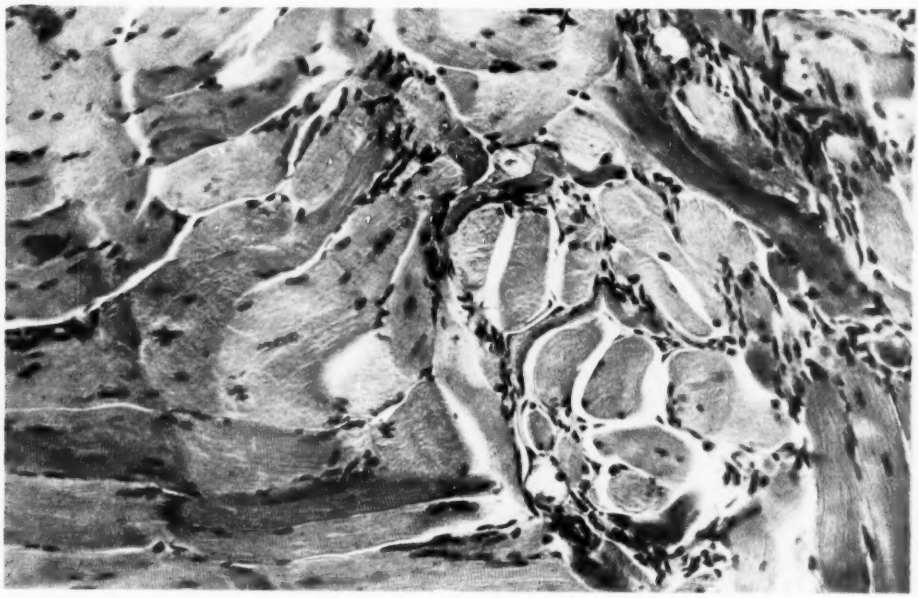

FIG. 13

Normal muscle eight weeks after crush. An irregular network of muscle fibres is all that marks the site of the crush. Most of the fibres are of normal diameter, and show normal cross-striation; fibroblastic tissue is much diminished, but a few fibroblastic nuclei can still be identified between the muscle fibres (× 220).

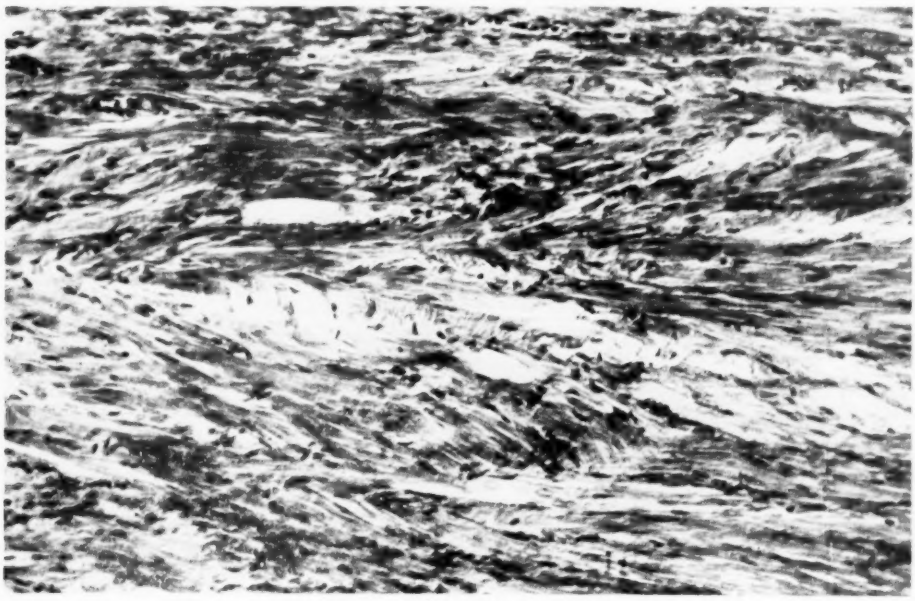

FIG. 14

Denervated muscle, eight weeks after crush. The regenerated fibres are slender, but they show clear cross-striation (× 220).

granulation tissue into which they are advancing (Fig. 7). In one specimen, for instance, these bulbous terminations were very numerous where a tendinous intersection lay across the path of the regenerating fibres. Their distribution is consistent with Clark's suggestion that these enlargements are produced by obstructions to the outflow of muscle cytoplasm. At one week the muscle shows a less intense inflammatory reaction than at four days.

Two to five weeks—During this period the effectiveness of repair increases (Figs. 9 and 11). More and more fibres bridge the gap, and they take on an increasingly mature appearance. Their cross-striation is now uniformly developed, and most of them have lost the basophilic staining of the earlier stages. In a few areas, however, slender fibres, identical with those present at an earlier stage of regeneration, are still seen, but these diminish in number as the weeks pass. Fibroblastic granulation tissue, so conspicuous at one week, also decreases until, by five weeks, usually only a few small areas are present.

Where sarcolemmal tubes remained intact, the structural pattern of the new fibres is normal, but where they were destroyed the fibres are irregularly woven together (Fig. 11). New sarcolemmal tubes are found around regenerated fibres, and appear to be formed simply by condensation of fibroblasts and collagen fibres on the surface of the muscle fibres.

Later stages (six to thirty-two weeks)—After about six weeks the site of the crush has usually become inconspicuous, both to the naked eye and on histological examination (Fig. 13). It is sometimes impossible to detect the slightest abnormality in the previously damaged area, even though in some cases it had been marked by placing a thread at the time of injury. More often the area is identified by some irregular interlacing of the otherwise parallel muscle fibres. An occasional regenerated fibre may still have more than the normal number of nuclei, and in one six-week specimen a few slender regenerating fibres were still present. Occasionally small areas of residual fibrous tissue may be found.

INJURY OF DENERVATED MUSCLE

Histology of denervated muscle—After section of the sciatic nerve, the gastrocnemius muscle shows progressive atrophy (Figs. 1 and 2). The diameter of individual muscle fibres is greatly reduced, and sarcolemmal nuclei—whether by active proliferation, or by mere shrinkage of fibres—become more conspicuous than in normal muscle. Longitudinal myofibrils and cross-striation persist. Individual fibres show some variation in the extent and rate of atrophy, but by three weeks the loss in volume of the denervated muscle is considerable; most fibres show pronounced histological changes, and Wallerian degeneration of the nerves is complete. For these reasons, three weeks was chosen as the period of denervation at which to crush the muscle and to investigate repair. After this period the denervated muscle shows continued wasting and atrophic change. Eventually fibrosis develops and few muscle fibres remain.

Regeneration of denervated muscle—The general process of muscle repair as seen in sections of denervated muscle after crushing injury is the same as already described in the normal control preparations. As the following descriptions show, only minor differences can be found when the two groups are compared.

Immediate response—Apart from the presence of denervation atrophy, the picture in the hours following injury—interruption and necrosis of muscle fibres, and haemorrhage in the crushed region—is like that in normal muscle.

After two days, phagocytosis of muscle fibres is taking place (Fig. 4). It appears to be more complete than in the normal muscle, presumably because of the smaller bulk of the necrotic fibres. Empty sarcolemmal tubes are present, and there is some formation of fibroblastic granulation tissue, but no evidence of regeneration of muscle fibres is found.

Four days—As with the normal muscle, the denervated specimens show active growth of slender regenerating fibres into the damaged area by four days. The denervated fibres from which these arise are more slender than normal fibres, but the outgrowths have the same

histological appearance as those developing in normal muscle. In some areas the new fibres grow along sarcolemmal tubes (Fig. 6) and, as was noted with normal muscle, it is in these areas that their rate of growth is greatest. Phagocytosis of necrotic fibres is still active and, as at the two-day stage, it is more complete in the denervated muscle than in the normal.

One week—At this stage, many of the newly developed fibres of the denervated muscle have bridged the crushed area. The extent of their outgrowth depends, as does that of regenerating fibres in normal muscle, on the extent of disorganisation of sarcolemmal tubes (Fig. 8). Occasional new fibres show cross-striation, and when the path of the growing fibres is blocked by fibrous tissue the same bulbous club-like terminal enlargements that are found in normal muscle are produced. As in the normal controls, fibroblastic proliferation is conspicuous at this stage.

Two to five weeks—More and more of the crushed area becomes occupied by newly developed fibres, and fibroblastic tissue becomes less conspicuous. The course exactly resembles repair in the normal muscle (Fig. 10), except that the maturing fibres achieve only the thickness of the surrounding denervated muscle fibres.

Later stages (six to thirty-two weeks)—After six to eight weeks it is often difficult or impossible to recognise the region of the crush because of extreme atrophy of muscle fibres. As part of the denervation changes, the entire muscle may show some degree of fibrosis by the end of this period. If, however, the site of the crush can be recognised, it is distinguished, as in the controls, by irregularly interlacing muscle fibres (Fig. 12). In one thirty-two-week specimen the site was clearly indicated by this feature.

DISCUSSION

During the course of these experiments we studied a paper by Kirby, who we found had demonstrated in 1892 the regeneration of muscle fibres under conditions of complete denervation. Using rabbits, Kirby produced ischaemic necrosis of part of the gastrocnemius by ligating it for three hours, and investigated the regeneration of muscle fibres into the necrotic area. He found that previous severance of the sciatic nerve did not retard regeneration. We bring forward our own findings, however, because they allow a more detailed comparison of the cellular processes of muscle repair in normal and denervated muscle. Moreover, in spite of the interest in muscle regeneration that has been aroused by the recent papers of Clark and Blomfield, few people are aware of Kirby's earlier work in this field.

The experiments described in the present paper show that, after a simple crushing injury, the fibres of a totally denervated muscle regenerate in the same manner as those of normal muscle. Moreover, the final effectiveness of the msucle repair is the same in the denervated tissue as in the normal, and the intermediate stages of repair are exactly comparable in the two groups.

The active repair of denervated fibres plays its part even in a crush injury of normal muscle, because in such lesions nerve stains revealed extensive nerve damage in the neighbourhood of the crush. Many of the regenerating muscle fibres must have been without their nerve supply.

Both in normal and denervated muscle, our findings are consistent with the view that the regeneration of muscle fibres takes place from the ends of damaged fibres adjacent to the crushed area. No evidence of metaplastic formation of muscle fibres from connective tissue cells was seen.

Again, both in normal and in denervated muscle, the direction and the rate of regeneration of individual muscle fibres depend alike on the presence or absence of intact sarcolemmal tubes. In their presence, a normal pattern of muscle fibres is quickly re-established, and regenerating fibres grow as much as three millimetres in two days or less (that is, between the second and fourth days). Where sarcolemmal tubes are destroyed, and the regenerating

fibres encounter vascular granulation tissue, an irregular pattern of interlacing muscle fibres results, and the effective rate of repair is much less. In these experiments the superficial part of the crushed muscle, over a distance rather greater than the crush itself, often showed the less severe type of injury with preservation of sarcolemmal tubes and in these areas rapid and effective regeneration had taken place. In the early stages of the work it was not clear whether these slender fibres on the surface of the innervated muscle specimens near the crush represented regenerated or denervated fibres. But the fact that they were conspicuous within one week of injury, when denervation atrophy could not have accounted for fibres of such small diameter, as well as their presence in the previously denervated specimens, established that they were regenerated fibres. Moreover, the presence of regenerating fibres, growing rapidly within sarcolemmal tubes as early as four days after injury, explained the method of their formation.

Both in the normal and denervated muscle, the fibroblastic tissue that develops during the first week after the crush soon disappears. At a later stage, some fibrous tissue may develop in the denervated muscle as part of its progressive atrophy, but the "scar" in the normal muscle consists only of regenerated muscle fibres.

In these experiments, as in those of most other writers on the subject, mitoses of muscle nuclei have not been observed, although the regenerating fibres contain large numbers of nuclei which are often strung end to end along their length. In contrast, the connective tissue surrounding the regenerating muscle fibres contains many mitoses in the days following the crush. Surprisingly enough, the regenerated fibres, both in normal and in denervated muscle, develop conspicuous cross-striation at an early stage in their maturation.

SUMMARY

1. The repair of a simple crush injury was studied in rats, in both normally innervated and completely denervated muscle. In each case the histological findings at periods from two hours to thirty-two weeks are described.

2. The denervated muscle showed active and effective repair.

3. A comparison with the findings in normally innervated muscle establishes that the cellular processes of repair do not depend on connections with the central nervous system.

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THE EFFECT OF CORTISONE ON THE REGENERATION OF SKELETAL MUSCLE AFTER INJURY

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The administration of cortisone to experimental animals is known to inhibit the growth and regeneration of a variety of tissues. The normal increase in weight of a growing animal may be prevented or reduced (Wells and Kendall 1940, Winter *et al.* 1950), and the growth of hair, which is an indication of the proliferation of the skin, ceases (Baker and Whitaker 1948, Winter *et al.* 1950, Ingle 1950). The formation of granulation tissue in a skin wound (Ragan *et al.* 1949), and the development of fracture callus (Blunt *et al.* 1950, Sissons and Hadfield 1951) are also inhibited.

In a group of animals studied primarily from the point of view of fracture repair (Sissons and Hadfield 1951), the writers investigated also the repair of muscle tissue after a local crushing injury. The present paper describes the results so obtained.

METHOD

Rabbits were used because of their known sensitivity to the depressing effects of cortisone on tissue repair. Two groups were treated with cortisone, given by daily subcutaneous injection throughout the period of the experiment; the amounts of cortisone administered were respectively 10 and 20 milligrams kilogram day. The rabbits were young growing animals, and these dosages were sufficient to arrest their growth, and to produce considerable muscle atrophy which steadily increased in the three weeks during which the animals were studied. After three days of cortisone administration a standard muscle crush, by the technique of Clark (1946), was carried out under ether anaesthesia. In this procedure the lateral part of the gastrocnemius muscle was crushed transversely with smooth-bladed artery forceps, producing a zone of damage three millimetres wide, where muscle fibres were necrotic and fragmented. Retraction of the undamaged muscle is prevented by the connective tissue stroma that remains in the crushed area. An equal number of untreated control rabbits received a similar muscle crush. In the 20-milligram group, cortisone-treated and contol animals were killed at intervals from three to twelve days after injury, and the crushed muscles were examined histologically. In the 10-milligram group, animals were killed at intervals up to twenty-one days after injury, and were similarly studied. The injured muscles were fixed in Helly's fluid, and sections were stained with haematoxylin and eosin, and by the tartrazine and lissamine fast red technique (Lendrum 1947).

OBSERVATIONS

Regeneration of muscle in control animals. The histology of muscle regeneration has been recently summarised by Clark (1946), and by Saunders and Sissons (1952).* The findings in the present control animals are consistent with these accounts of the subject, and can be described briefly as follows. Three days after the injury, the site of the crush is marked by

* Published in this number of the Journal.

necrotic muscle fibres and extravasated blood. Vascular granulation tissue is present (Fig. 1) and active phagocytosis of the necrotic muscle fibres is in progress. Numerous mitoses can be identified in the fibroblasts of the granulation tissue. At about this time the earliest regeneration of the muscle fibres themselves is apparent. The intact muscle fibres at the margin of the damaged zone send out slender strap-like protrusions into the gap. These regenerating fibres grow in sarcolemmal tubes in areas where these structures are intact, and in the interstices of vascular granulation tissue where they have been destroyed (Figs. 3 and 4). The fibres are more basophilic than mature muscle fibres, and at first they are without cross-striation.

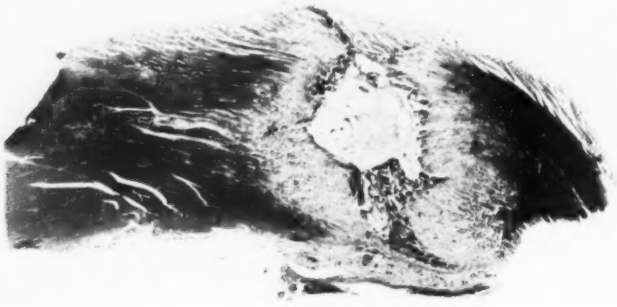

FIG. 1

Control, four days. A general view of the crushed region. A few necrotic muscle fibres are present, and the central haematoma is surrounded by a zone of oedematous granulation tissue in which outgrowth from undamaged muscle is beginning (× 7).

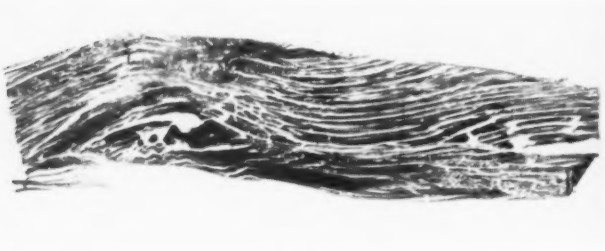

FIG. 2

Cortisone, 20 milligrams, four days. There has been little or no phagocytosis of necrotic muscle fibres at the site of the crush, and none of the reactive features of the normal specimen are seen (× 7).

Seven days after injury, the phagocytosis of necrotic muscle is complete, and the slender regenerating muscle fibres have advanced to occupy much of the damaged tissue (Fig. 6). The new fibres show occasional bulbous terminal enlargements containing numerous nuclei, and they are developing characteristic cross-striation. At this stage many fibres have extended completely across the crushed area.

During the second and third weeks after injury the crushed zone looks increasingly normal. More and more muscle fibres bridge the gap, and the regenerated fibres increase in diameter and take on a more mature appearance. Vascular granulation tissue decreases in amount, and some irregularity in the pattern of the muscle fibres is all that indicates the site of the lesion.

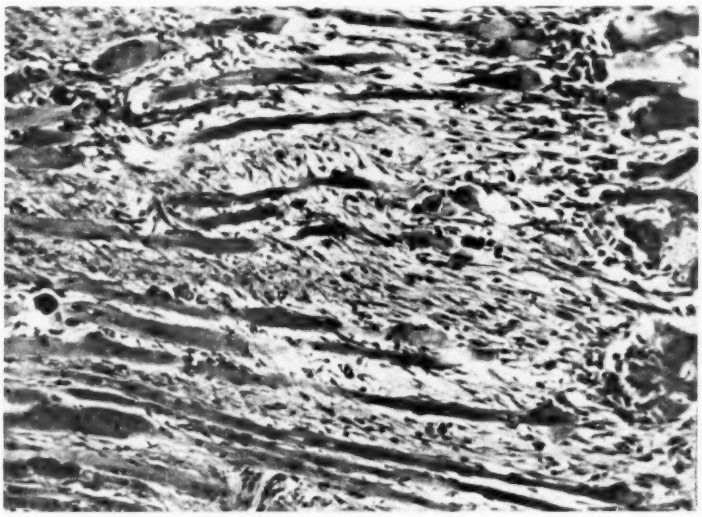

FIG. 3

Control, four days. The remains of some necrotic muscle fibres are seen to the right of the field. Numerous regenerating fibres are present, with newly formed fibroblastic tissue between them (×140).

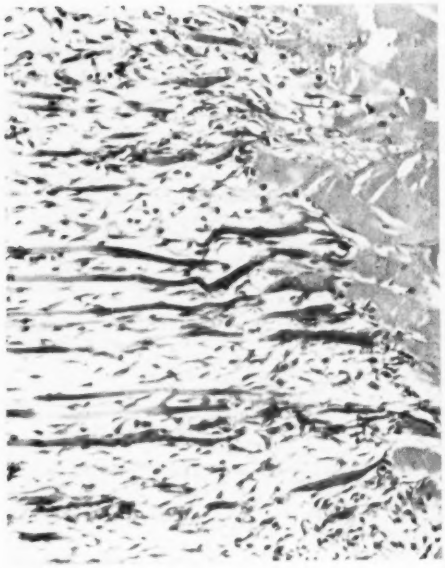

FIG. 4

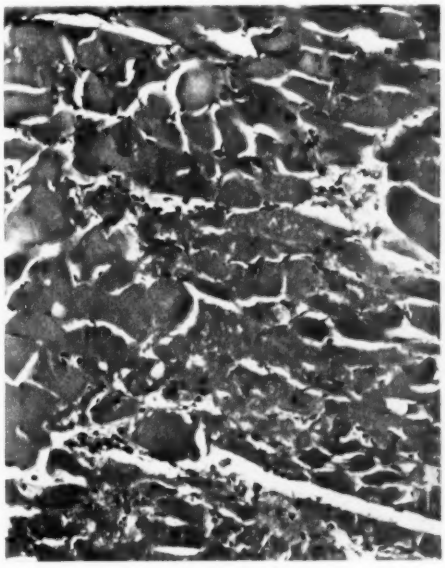

FIG. 5

Figure 4—Control, four days. Showing slender regenerating muscle fibres at the margin of the crushed area (×140). Figure 5—Cortisone, 20 milligrams, four days. The crushed area shows necrotic fibres, but there is no phagocytosis or muscle regeneration (×140).

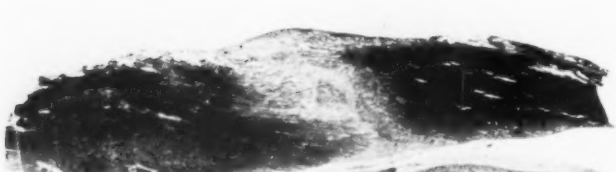

FIG. 6

Control, seven days. Showing the further outgrowth of regenerating muscle fibres into the crushed area (×7).

FIG. 7

Cortisone, 20 milligrams, seven days. Necrotic fibres still remain in the crushed zone, but the outgrowth of regenerating fibres can now be seen (×7).

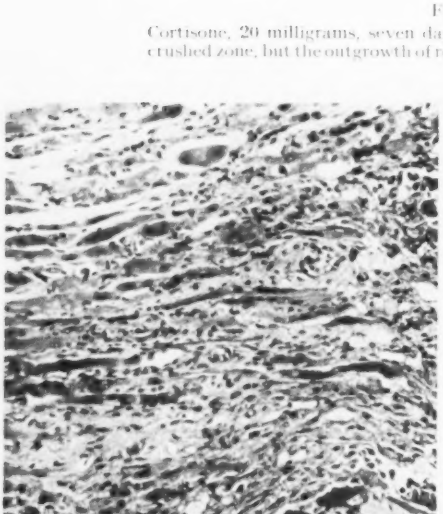

FIG. 8

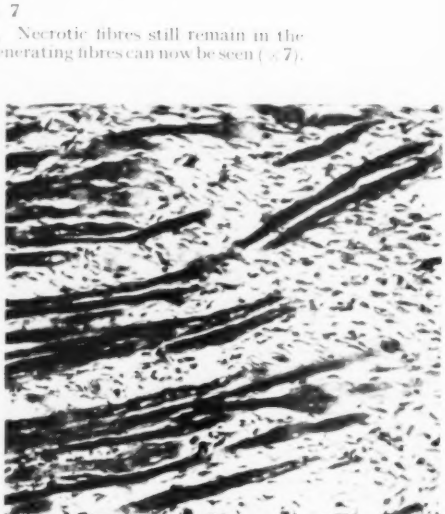

FIG. 9

Figure 8—Cortisone, 20 milligrams, seven days. Regenerating muscle fibres. Note the collections of necrotic fibres still present (×140). Figure 9—Cortisone, 10 milligrams, eight days. Regenerating muscle fibres (×140).

Regeneration of muscle in animals receiving cortisone—Within three to four days after injury, in animals receiving either 10 or 20 milligrams of cortisone per kilogram per day, there is marked interference with the response to injury (Figs. 2 and 5). Muscle fibres in the crushed area are necrotic, and haemorrhage has occurred, but the cellular and vascular changes found in the normal material are absent. Granulation tissue is not seen, and there is complete absence of phagocytosis of the necrotic muscle fibres (Fig. 5), so that the extent of the lesion can be determined only by the identification of necrotic fibres under the higher powers of the microscope. This contrasts with the findings in the normal animals, in which the area of damage is clearly demarcated at this stage. No regeneration of muscle fibres is seen, although it is present in the control material.

Seven to eight days after injury, the area of damage has become demarcated (Fig. 7), although necrotic fibres, at this stage completely phagocytosed in control animals, are still present. Some granulation tissue, apparently of normal vascularity, has now been formed in the gap between the muscle ends and, for the first time, slender regenerating muscle fibres are seen growing into this tissue (Figs. 8 and 9). These fibres are morphologically identical with their counterparts in the control material, though they have not extended so far into the gap as those have done.

By eleven to twelve days the appearances in both groups of cortisone-treated animals are still alike. Unphagocytosed necrotic muscle fibres are still present, but active muscle regeneration is in progress. Repair, however, has not proceeded to the same stage as in the controls, in which the gap in the muscle has now been almost completely closed by regenerated fibres.

In the later stages studied in animals receiving the smaller dose of cortisone, which were killed at intervals up to twenty-one days after injury, lesions show progressive muscle repair with eventual closure of the gap by regenerating fibres from the opposed ends of the crushed muscle. Even at twenty-one days, however, a few unphagocytosed necrotic fibres are still present, and are completely surrounded by regenerated muscle fibres. At all stages in the process of repair, some of these necrotic fibres show calcification (Figs. 7 and 8), a feature absent in any of the controls.

In the cortisone-treated animals not only is the beginning of muscle repair deferred but, as far as can be estimated, the rate at which the regenerating fibres ultimately grow out into the granulation tissue of the crushed area is slower. It may be that some closure of the gap by approximation of the muscle ends aids repair, but it is to be stressed that the gap is eventually obliterated by the same irregular interlacing of muscle fibres that occurs in the control animals.

In some animals of the second group (receiving 10 milligrams of cortisone/kilogram/day) to which cortisone had been administered for more than twelve days, occasional focal areas of necrosis were seen in muscle tissue remote from the crushed areas. These took the form of short or long segments of individual muscle fibres, the only change being necrosis and hyalinisation of the muscle cytoplasm. Phagocytosis of the necrotic material was not apparent, and there was little or no cellular reaction. Histologically, these lesions, apparently the result of prolonged cortisone dosage, are similar to the "toxic" necrosis of muscle—"Zenker's degeneration"—occasionally found in typhoid fever and other general infections, and to the focal necrosis of muscle recently reported (Smith *et al.* 1950) in dogs maintained on a diet deficient in potassium.

DISCUSSION

The material described shows that the administration of cortisone, although deferring the onset and retarding the rate of muscle regeneration after a simple crushing injury, does not change the course or eventual outcome of this process.

It is difficult to compare the process of repair in such different tissues as muscle and bone, but when it is recalled that in these same experimental animals the development of fracture

callus was seriously inhibited (Sissons and Hadfield 1951), and that as late as twenty-one days after injury there was no evidence of any union between the fragments, it is hard to escape the conclusion that the process of repair in bone is more sensitive to cortisone than that in muscle. Whereas the regeneration of bone, cartilage, fibrous tissue and blood vessels depends on the mitotic division of cells, regeneration of muscle is brought about by the extension of a severed cytoplasmic syncytium. Mitotic activity, moreover, has never been detected in regenerating muscle fibres. Perhaps these differences may play a part in determining the differing sensitivity of the two processes to inhibition by cortisone.

The delay that normally occurs before the commencement of the regeneration of muscle—and of other connective tissues—after injury, and the further deferment and retardation of these processes by cortisone administration, raise the question whether the initial delay may not be part of the "stress syndrome" produced in the experimental animals by the injury, and brought about by adrenal hyperactivity. If subsequent experimental work shows this to be the case, the eventual completion of repair under conditions of continued cortisone administration would need further explanation.

SUMMARY

The effect of cortisone on the repair of simple muscle injury was studied in rabbits. The histological findings in the crushed muscle are described for a period up to twenty-one days after injury.

Cortisone defers the onset of muscle regeneration, and retards its progress, but it does not change the course of the repair process or alter its eventual outcome under the conditions of the experiment.

This apparent refractoriness of repair of muscle, as compared with that of other connective tissues, is discussed.

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THE BLOOD SUPPLY OF THE FLEXOR AND EXTENSOR TENDONS OF THE FINGERS IN MAN

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The present investigation was inspired by a desire to know something about the factors that produce stiffness of the fingers after injury or inflammation. It seemed logical to inquire whether there were any vascular changes in the fingers in these circumstances, first because in any reaction of a tissue to injury the blood supply is affected, and secondly because fingers that are stiff often undergo so-called trophic changes which may well be related to impairment of blood supply.

Before a study of disease processes could be carried out it was necessary to determine the normal vascular patterns of the tendons and joints of the fingers, more especially as the accounts in the literature are incomplete and sometimes contradictory. This paper deals with the normal blood supply of the tendons and tendon sheaths in man. It is intended in a second paper to describe the changes found in disease and after injury.

Historical note—It was long considered that tendons were avascular structures, and to-day the opinion of Kölliker (1850) is still repeated—that tendons have no blood supply. Ludwig and Schweigger-Seidel (1872) showed that intratendinous vessels existed, as did Mayer (1916). Mayer was chiefly interested in the operative surgery of tendons and gave only limited information about the blood vessels. But he did point out that tendons may receive blood vessels in four regions: 1) at the musculo-tendinous junction; 2) at the osteo-tendinous attachment; 3) in extra-synovial regions through the loose tissue surrounding the tendon (paratenon); and 4) in synovial regions through mesenteric attachments or synovial bands (vincula).

Edwards (1946) has added further to the knowledge of the internal arrangements of the tendon vessels. He showed that the vessels of a tendon are arranged around the collagen bundles of which tendon is composed, and that there is a simple blood-vascular system consisting of a series of longitudinal channels parallel to the collagen bundles, with frequent cross-anastomoses. Each intratendinous longitudinal channel is composed of a small arterial vessel accompanied by two small veins.

MATERIAL AND METHODS

The material studied has been entirely human; it has included fifty fingers, and several whole hands. Colloidal silver iodide was injected under controlled pressure into the digital arteries. The injection was continued until the silver iodide flowed freely from the veins. At this stage the veins were obstructed by a rubber band and the injection continued for three to four hours to obtain maximal filling of the vessels. Arteries, capillaries and veins were all filled by this technique. The material was dissected, fixed in 10 per cent formalin, developed photographically and then cleared in oil of wintergreen. An alternative method was the injection of Indian ink in plasma. Retrograde venous injection was found to be impracticable because of the presence of valves in the venous system.

OBSERVATIONS

The feeding vessels of the tendons. *Non-synovial regions*—Blood vessels reach the tendons in different ways in different parts of the hands and fingers. The simplest arrangement is

found in the distal part of the palm and in the forearm, where the flexor tendons have no tendon sheaths but lie in loose connective tissue (paratenon). Here vessels pass through the loose tissue at frequent intervals to supply the tendon (Fig. 1). They are arranged in curves

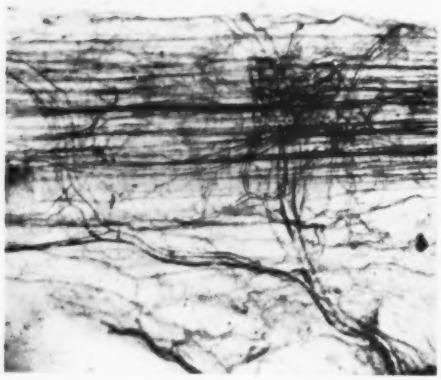

FIG. 1

FIG. 2

Figure 1—Flexor tendon in an extra-synovial region showing blood vessels passing to it through the loose connective tissue (paratenon) surrounding it (×7). Figure 2—Musculo-tendinous junction of flexor digitorum sublimis showing vessels passing to the muscular and tendinous parts (×9).

FIG. 3

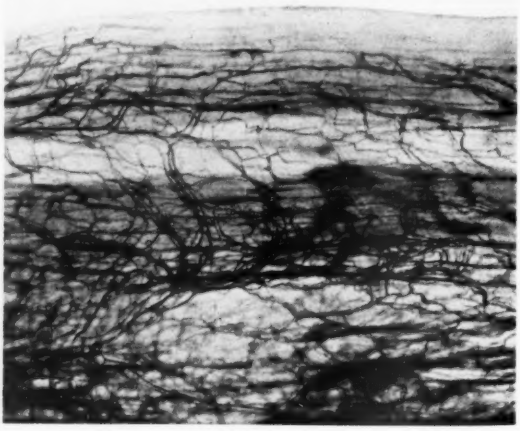

FIG. 4

Figure 3—Flexor digitorum sublimis tendon of the little finger showing the vascular arcades within the palmar bursa (×5). Figure 4—Two flexor digitorum profundus tendons lying within a reflection of the palmar bursa. Vessels entering from the proximal and distal ends of the bursa (×6·5).

so that when the tendon moves the curves are straightened out. The connecting vessels consist of an artery and two small accompanying veins, and there are frequent cross-connections between the veins. Usually one is considerably larger than its fellow and the diameter of

the veins is slightly greater than that of the artery. The extensor tendons are also largely without a synovial sheath, and are covered with paratenon, through which many vessels pass at frequent intervals to the tendon. The arrangement is similar to that found in other areas where there is no synovial covering.

In the region of the musculo-tendinous junction there are numerous feeding vessels which in some instances divide into two—one branch passing into the muscle and the other into the tendon (Fig. 2). Other vessels pass directly from the muscle belly into the tendon. The arrangement is in all respects similar to that found where the tendon has no synovial sheath.

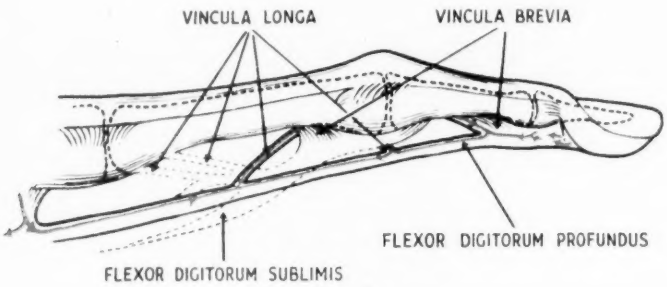

FIG. 5

Diagram of a main vascular channel of the flexor digitorum profundus tendon within the digit.

FIG. 6

Main vascular channel of a flexor digitorum profundus tendon within the synovial digital sheath (×10).

Synovial regions—Where the tendon lies within a synovial sheath the supplying blood vessels follow definite patterns. In the palm the flexor digitorum sublimis and the flexor digitorum profundus tendons lie within the palmar bursa. The four tendons of the latter lie parallel to one another on the deep aspect of the flexor digitorum sublimis. Although all the long flexors of the fingers lie within reflections of the palmar bursa, each of the tendons of the flexor digitorum sublimis has an incompletely separated mesotendon of its own. Between the visceral layers of the palmar bursa and the tendons there is a certain amount of loose connective tissue which is continuous both above and below the bursa with the paratenon.

The vessels that supply the tendon run in this loose connective tissue, and make many connections with those within the tendon substance. Through this loose connective tissue there is a sliding plane between the tendons and the visceral layer of the bursa; the connecting vessels are arranged to allow for this movement.

The flexor digitorum sublimis tendons are supplied by feeding vessels which form arcades between the two visceral layers of the bursa (Fig. 3), similar to those seen in the mesentery of the small intestine. The arcades are usually three in number and from the most distal row connections are made with the intratendinous vessels.

In the palmar bursa, the flexor digitorum profundus tendons lie together in connective tissue, sandwiched between two layers of visceral synovial membrane. The vessels supplying the tendons ramify in this tissue (Fig. 4), entering both at the proximal and distal ends of the bursa.

FIG. 7

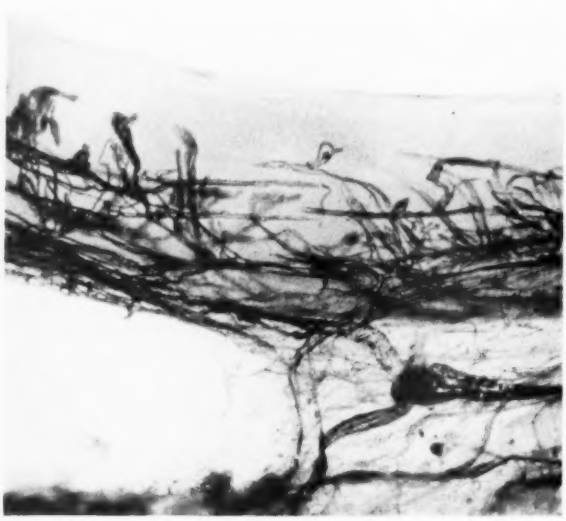

FIG. 8

Figure 7—Blood vessels of the vinculum longum of a flexor digitorum profundus tendon (× 15).
Figure 8—Vinculum brevium containing the main vascular channel close to the insertion of the flexor digitorum profundus tendon.

The blood supply to the tendons within the digital sheath differs from the arrangement in the palm. The visceral layer of the synovial membrane is closely adherent to the tendons without any loose intervening connective tissue, except in sites where friction is minimal. Vessels can only pass to and from the tendons at their insertions, through synovial bands (vincula) or at the points of reflection of the synovial sheath on to the tendons at the proximal and distal ends of the digital sheaths. There is a constant pattern of vessels supplying the tendons within the digital sheath. On the dorsum of the flexor digitorum profundus tendon there is a main longitudinal channel which originates in the palm and joins the tendon on its radial side. This channel rapidly attains a mid-dorsal position in which line the vessels continue as far as the insertion of the tendon (Fig. 5). The vessels comprise a small artery and two veins, surrounded by a little loose connective tissue deep to the synovial membrane (Fig. 6). It is likely that this is a position of minimal friction, and it is only in this dorsal position that the synovial membrane is not firmly bound down to the tendon. Joining this longitudinal channel at intervals are tiny vessels which run in the vincula (Fig. 7). These feeding vessels not only connect with the main channel but also send branches into the tendon

substance. Near the insertion of the profundus tendon into the distal phalanx the main dorsal channel turns along the synovial reflection (vinculum brevium) to join with transverse vessels which cross the neck of the intermediate phalanx (Fig. 8). From the vessels in this reflection branches pass towards the tendon insertion, which is also supplied by branches

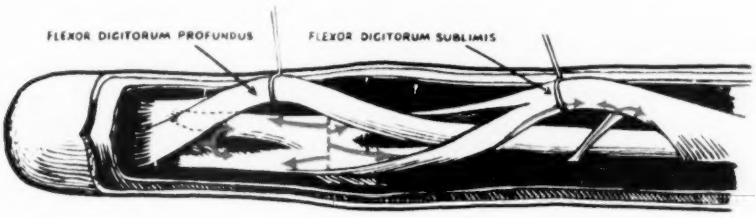

FIG. 9

Diagram of the main vascular channels of the intrathecal part of a flexor digitorum sublimis tendon.

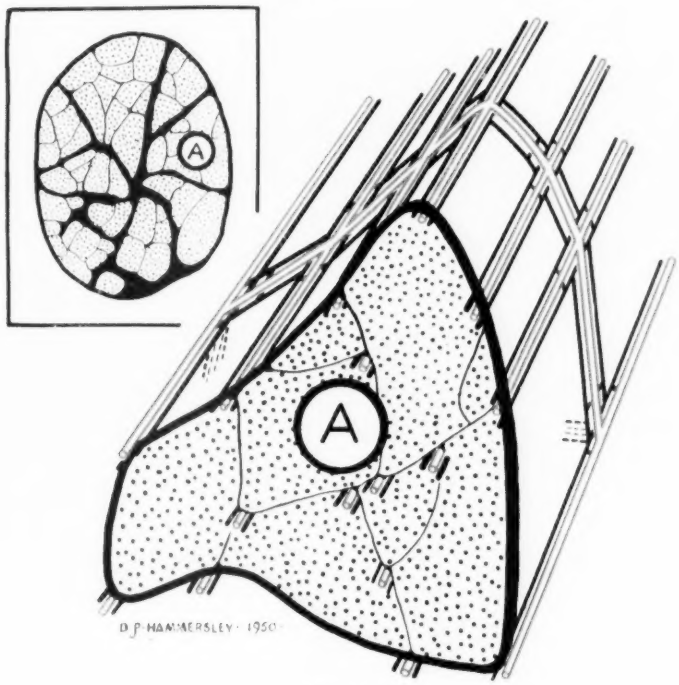

FIG. 10

Cross-sectional diagram of the vascularisation of a typical tendon showing the position of arteries and veins.

from the capsular vessels at the base of the distal phalanx. Comparatively few periosteal vessels take part in supplying blood to the tendon.

The flexor digitorum sublimis tendons also have main vascular supply channels, each comprising an artery and two veins, but the arrangement is more complicated than in the profundus tendons because of the way in which the flexor digitorum sublimis divides into two slips over the proximal phalanx. These slips pass on either side of the flexor digitorum profundus tendon to reach the anterior surface of the proximal interphalangeal joint, where

they join again. Here the innermost fibres decussate. Finally two slips separate to be inserted into the sides of the intermediate phalanx. The vascular system of the intrathecal part of the flexor digitorum sublimis centres around the proximal interphalangeal joint. Between

FIG. 11

Low power view of flexor digitorum profundus tendon rendered transparent to show the intratendinous vessels (×9).

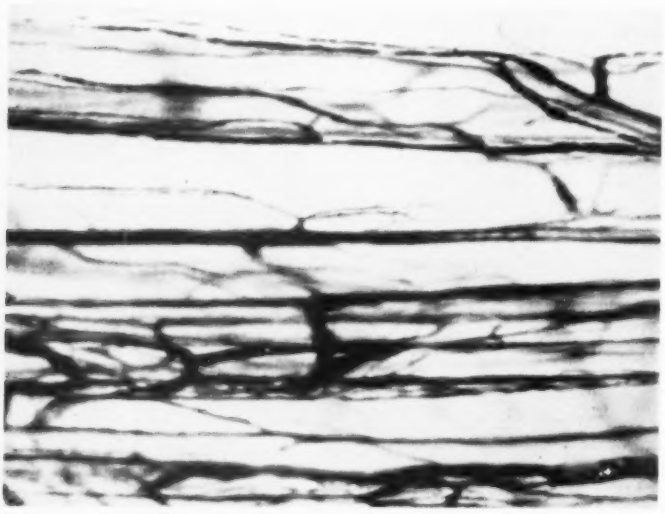

FIG. 12

Cleared specimen of flexor digitorum sublimis tendon to show intratendinous vessels (×38).

the two digital arteries at this level there are connecting vessels which also supply the capsule. From them vessels pass distally and proximally. A branch follows each slip of insertion to its termination in a distal direction. The second branch passes proximally around the flexor

digitorum profundus tendon with the slip of the flexor digitorum sublimis. These vascular channels are arranged in the form of a letter " H " centred over the proximal interphalangeal joint (Fig. 9). The channel which runs proximally receives communicating vessels from a

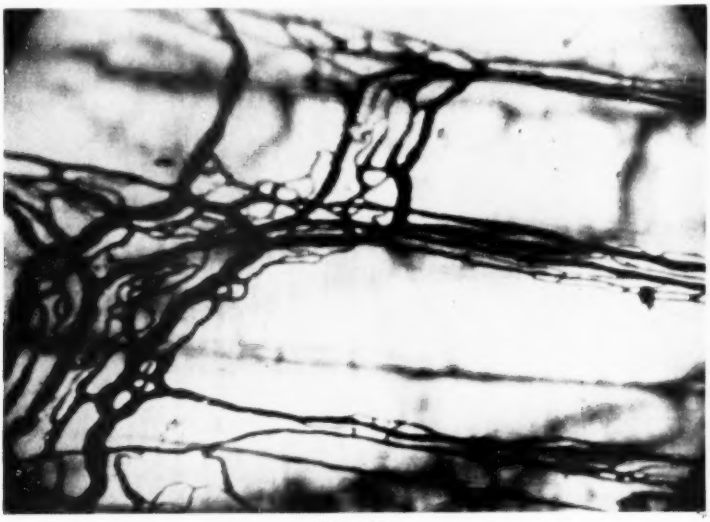

FIG. 13

Higher power view of two arteries, veins and capillaries arranged around two collagen bundles (× 95).

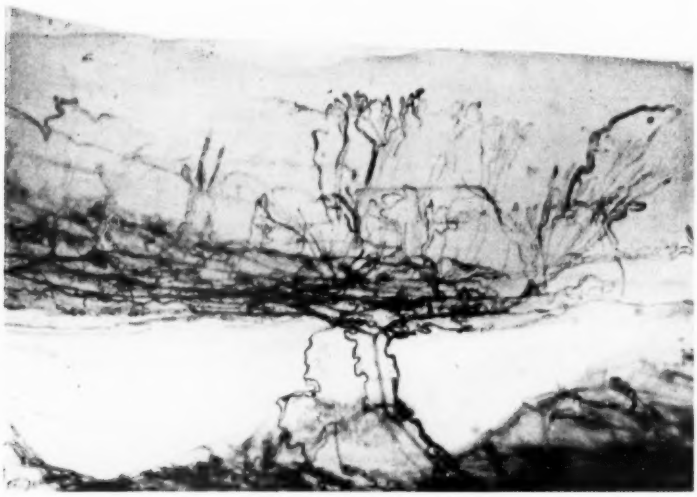

FIG. 14

Lateral view of cleared specimen of the flexor digitorum profundus tendon at the level of the proximal interphalangeal joint (× 10).

vinculum longum on the lateral edge of the slip. The arrangement is such that these vascular channels lie in positions of minimal friction.

Intratendinous vascular patterns—The vessels within the tendon lie in the interfascicular

connective tissue, which binds the collagen bundles together. The collagen bundle of fibres appears to be the vascular unit around which the blood vessels are arranged; arteries, veins and capillaries are all to be found in the interfascicular connective tissue but no blood vessels are demonstrable inside the individual collagen bundles (Fig. 10).

The blood-vascular system within the tendons of the hand consists of large numbers of longitudinal vessels lying parallel to the collagen bundles (Figs. 11 to 13). Each arteriole is accompanied by two venules; one venule is usually larger than the other and they communicate at frequent intervals. There are thus many more venous than arterial channels. The longitudinal intratendinous vessels connect with one another through transverse branches, which in turn connect with the main longitudinal vascular channel of the tendon.

This simple blood-vascular pattern is found throughout the flexor and extensor tendons of the hand with two exceptions, both of which occur in the flexor digitorum profundus tendon. In this tendon the longitudinal intratendinous pattern is upset at the level of the proximal and distal interphalangeal joints. Over the proximal interphalangeal joint, vascular loops are to be seen passing vertically through the tendon substance. These loops originate from either the main vascular longitudinal channel on the dorsal surface of the tendon or from the vascular twigs which pass to the tendon in the synovial bands (vincula longa). It may well be that the orientation of the vessels in a vertical direction in this region is related to the fact that the tendon is bent to a greater degree than any other tendon in the body during flexion of the proximal interphalangeal joint; so that if the vessels were not so arranged, the blood flow in the tendon at this point would be obstructed by flexion of the finger (Fig. 14).

Over the distal interphalangeal joint the regular vascular pattern is again disturbed (Fig. 8). At this site vessels reach the tendon along the vinculum brevium, and many branches arise which pass through the tendon to join the fine longitudinal vessels running between the collagen bundles.

SUMMARY

The blood supply of the flexor and extensor tendons of the fingers is described. The blood-vascular system consists of main feeding channels which supply a longitudinal network of vessels. These lie in the interfascicular connective tissue.

A variation of the typical intratendinous vascular pattern in relation to the proximal interphalangeal joint is described.

I should like to thank Professor F. H. Bentley and Mr F. Braithwaite for their helpful criticism of this work, Mr Wilson for the histological preparations, Messrs Ridley and Leslie for the photography and Mr D. P. Hammersley for the illustrations.

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Alfred Herbert Tubby

Alfred Herbert Tubby played a leading part in the development of orthopaedic surgery, particularly during its transition from the period of tenotomy and appliances to that of open operative correction of deformity.

He derived from South Country yeoman stock and was born on May 23, 1862, the son of Alfred Tubby, a corn merchant living in Great Titchfield Street, London, and his wife Frances, née Roe. A few months after the child's birth his father died. He was educated at Christ's Hospital, then in Newgate Street, London, where he had as schoolfellow F. J. Smith who was to become Tubby's colleague on the staff of the National Orthopaedic Hospital and a well known physician to the London Hospital; author of a standard work on medical jurisprudence. Tubby in later years was Consulting Surgeon, Governor and Almoner to Christ's Hospital. On leaving the Bluecoat School he proceeded to Guy's Hospital where he distinguished himself as a prizeman, qualifying in 1884 as a Member of the Royal College of Surgeons. At the final medical examinations of London University in 1887 he won the gold medal in medicine and the gold medal in surgery besides gaining honours in anatomy, materia medica and forensic medicine; the same year he became a Fellow of the Royal College of Surgeons. He proceeded to the degree of Master of Surgery in 1890. At different periods he studied at Halle and Leipzig; it was this German training that attracted him to the work of Lange and Vulpius on tendon transplantation in infantile paralysis.

STUDIES OF TENDON REPAIR

Tubby was appointed senior demonstrator of physiology at Guy's Hospital and while occupying this post he carried out important researches on tendon repair, employing new staining methods he had learnt from Beneke of Brunswick. The Achilles tendons of full-grown rabbits were divided with antiseptic precautions, the punctures being protected with gauze. The animals were killed at intervals from three days up to thirty-three weeks, one at thirteen months after tenotomy. His observations on the microscopic sections were reported in 1892 in the Pathological Society's Transcations and Guy's Hospital Reports: "With reference to the influence of effused blood it was shown that for firm union to take place, sufficient blood must be poured out to fill the tendon sheath so that it retained its tubular form to the same degree as before operation, and further, that the effused blood formed a pabulum or nidus for the large plasma cells. That the tendon is not capable of perfect regeneration, even after thirteen months, was shown by the fact that the fibrous tissue of the bond of union was not arranged in parallel striae, and that the square fixed tendon cells were not found in it. As to the tissue, which was mainly instrumental in forming the new fibrous tissue, it was quite clear that the square fixed tendon cells took no part, that the leucocytes merely a subordinate one, and that the chief agents in the whole process were the large plasma cells having the following characteristics: They are frequently multi-nucleated, they have several processes and are full of granular protoplasm. The modus operandi is as follows:—At first the effusion consists of red blood corpuscles, fibrin and leucocytes. The first two rapidly disappear, the latter more slowly under the influence of the plasma cells, which migrate from the cut ends of the tendon and from the tendon sheath. They seem to gradually absorb the leucocytes and take their place. These plasma cells subsequently develop into fibrous tissue and form also the cell-walls of temporary blood-vessels which run through the scar-tissue."

In 1891 Tubby became surgeon to the Evelina Hospital and to the National Orthopaedic Hospital. In 1894 he was elected assistant surgeon to Westminster Hospital and four years later became surgeon, an appointment he held for thirty years. He was given charge of the orthopaedic department and lectured on clinical and orthopaedic surgery. He also served as Dean of the Medical School, an office in which his keen business instincts were of value to the administration of the hospital. He was also consulting surgeon to the Hospital for Hip Disease, Sevenoaks.

BRITISH ORTHOPAEDIC SOCIETY

In 1894 Tubby was elected joint secretary of the newly formed British Orthopaedic Society, whose avowed object was the advancement of orthopaedic surgery. This body came into being after an informal discussion between a group of surgeons interested in the surgery of deformities, who met at Bristol during the Annual Meeting of the British Medical Association. Meetings were held in London or a provincial centre, the programme consisting of clinical demonstrations, papers and discussions. Thus on May 24, 1895, the Society visited the Royal Infirmary and Southern Hospital, Liverpool; at the Medical Institution Robert Jones introduced a discussion on the treatment of intractable talipes equinovarus, demonstrating a remarkable number of patients cured of this stubborn deformity. But the Society lasted only for about four years; it published three slender volumes of its transactions which serve as a permanent record of an early effort to bring orthopaedic surgeons together to discuss their art and make social contact. The Society was a forerunner of the British Orthopaedic Association and in one way was more fortunate than its greater successor in that all its gathered grain was brought together into its own storehouse, whereas the Association unwillingly scattered its harvest for many years before it was able to shelter its products under its own roof.

IMPORTANT PUBLICATIONS

In 1896 Tubby published a book entitled *Deformities; a treatise on orthopaedic surgery* (Macmillan & Co.). It was the best work on orthopaedic surgery that had yet appeared in England and was something of a landmark in the development of this branch of surgery. It was based mainly on the experience the author had gained at the National Orthopaedic Hospital and the Evelina Hospital for Sick Children. He drew on his own hospital case notes; of the lavish number of illustrations produced two hundred were original. But he cast his net widely in order to gather the thinking and practice of surgeons in America and the Continent. The work was an authoritative presentation of orthopaedic surgery as understood in the closing years of the nineteenth century; it revealed how great had been its progress since W. J. Little in 1839 published his classic *A Treatise on Club-Foot and the Nature of Analogous Distortions*. But Tubby felt that this branch of surgery had still to reach maturity; a passage in the preface of his book makes strange reading: "The practice of Orthopaedic Surgery in England does not include all phases of diseases of bones and joints such as tuberculous ostitis and arthritis of the hip and knee, on what grounds it is difficult to understand." There is an admirable description of tuberculosis of the spine in the first three chapters but skeletal tuberculosis is never mentioned again. Congenital and acquired deformities are dealt with on a regional basis. There is a whole chapter on the deformities of rickets, a very prevalent disease at the time. The author's researches on tendon repair are described at length.

During the last decade of the last century tendon transplantation attracted widespread attention. This operation was first performed by Nicoladoni in 1882 when he attached the peronei to the tendo achillis in a patient with talipes calcaneus. In 1892 Parish and Drobnik independently applied the same method to other forms of foot paralysis. In 1894 Winkelman analysed a series of cases in which he had performed the operation. This was followed by a

Alfred Herbert Tubby

1862-1930

series published by Goldthwait; and Townsend wrote on tendon transplantation in the hand. The last paper read before the British Orthopaedic Society in 1898 was one by T. H. Openshaw on tendon transplantation.

COLLABORATION WITH SIR ROBERT JONES

In 1903 A. H. Tubby collaborated with Robert Jones in publishing a book on *Modern Methods in the Surgery of Paralysis* (Macmillan & Co.). The work consisted of a summary of all that had been done by tendon transplantation and arthrodesis in the treatment of paralysis together with their own experience of these methods. The many indications for tendon transplantation and its technique were described. Their treatment of spastic paralysis was an innovation; little had been attempted for this type of patient; indeed physicians discouraged surgery. The authors advocated tenotomy of adductors, hamstrings and tendo achillis and nursing the patient on an abduction frame or Thomas's calipers in abduction, to be followed by re-education walking exercises. By these procedures they were able to get these patients walking and capable of instruction. For the spastic pronated hand the pronator radii teres was converted into a supinator by detaching its insertion, with periosteum, passing it through the interosseous membrane, behind the radius and re-attaching it to the outer side of the bone. Flexor carpi ulnaris was transplanted into extensor carpi ulnaris and flexor carpi radialis into the radial extensors. Arthrodesis was sometimes combined with tendon transplantation in patients with infantile paralysis; more often fusion of the ankle was carried out. They had performed over a hundred such operations. The publication of this work half a century ago was a distinct landmark in the progress of orthopaedic surgery.

In 1912 Tubby published a new edition of his text-book with the ominous title *Deformities including Diseases of the Bones and Joints*. Sixteen years had passed since its first appearance and during the interval the whole field of orthopaedic surgery had greatly advanced, with a corresponding literature dealing with it. He had been obliged to rewrite the whole work and to arrange the various subjects according to their etiology and pathology rather than on a regional classification as in the previous edition. Such was the accumulated material that the author had to issue the work in two large volumes, which contained seventy plates and more than a thousand illustrations, of which four hundred were original. In 1896 Tubby protested at the exclusion of diseases of bones and joints, apart from the spine, from the province of orthopaedic surgery. In 1912, in the following words, he boldly declared that orthopaedic surgery is the surgery of the entire locomotor apparatus: " In England, contrary to the custom abroad, works written on ' Orthopaedic Surgery,' although they have dealt with tuberculosis of the spine, have not included tuberculosis and many other forms of diseases of the bones and joints elsewhere. And this in spite of the obvious fact that in the practice of Orthopaedic Surgery a surgeon is constantly called upon to deal with such morbid conditions and their results. It has been my attempt to remedy this somewhat illogical state of affairs, and to treat the subject from its actual standpoint which is the surgery of the entire locomotor apparatus, dealing not only with actual deformities, but also with those morbid processes which involve potential deformity. It is not claimed that the scope of the orthopaedic surgeon's work is thereby enlarged, since he undertakes already the treatment of malformations and deformities of the muscular and osseous systems, which demands a full acquaintance with the pathology of such conditions and with the essential therapeutic methods. A considerable portion of the work has therefore been devoted to a description of arthritic and osseous diseases, as indicated by the amplification of the former title into ' Deformities, including Diseases of the Bones and Joints: a Text-Book of Orthopaedic Surgery.' " This publication had the appearance of a work of reference; the whole world literature had been well sifted, to which Tubby's many contributions were added. Each subject was well balanced; etiology, pathology and treatment were given proper consideration. It was the best work on orthopaedic surgery in any language and has scarcely been equalled since. The clear descriptive

power of the author was not least of its features. Its reading still imparts a peculiar delight and that not without profit.

WAR-TIME ACTIVITIES

Within three years of the publishing of this great work on orthopaedic surgery the upheaval of the first world war occurred. Tubby, who had held a commission as Major in the Royal Army Medical Corps since the inception of the Territorial Force, was called up for service to the Fourth London General Hospital with the rank of Lieutenant-Colonel. In 1915 he was seconded for service as Consulting Surgeon to the British Mediterranean Force, with the rank of Colonel, Army Medical Service, but was soon transferred to the Egyptian Expeditionary Force. He was stationed at Alexandria with Sir Victor Horsley as his colleague until Horsley was transferred to Mesopotamia. His war experiences were related in a book, *A Consulting Surgeon in the Near East*, published in 1920. He gave a graphic account of the Gallipoli Campaign, of the sufferings of the troops, and the difficulties with sanitation which had to be surmounted. He organised fracture and orthopaedic treatment in Egypt but was unable to get sanction for segregation of fracture patients or special hospitals for their treatment. He had much to say about the duties of a consultant and offered helpful criticism about his relation to the establishment and the need for facilities for consultants of different groups to meet and discuss their problems; a consultant often found himself isolated.

He returned to civilian practice in 1919 and afterwards contributed a series of articles to the *Clinical Journal* which in 1925 were published in a small volume entitled *The Advance of Orthopaedic Surgery*. In 1928 he made his last contribution in the form of a well illustrated article in the *Lancet* on the selection and standardisation of surgical instruments, with microscopic photographs of knife blades, examining their hardness and ascertaining the effect of the stainless process upon them. He concluded that the economy and labour-saving advantages obtained by using stainless steel instruments were warranted by the fact that the metal suffered no loss of hardness.

INTERESTS IN ART AND SCIENCE

Tubby was a man of wide culture and many interests. He was an excellent linguist, an archaeologist, an Alpine climber, a sportsman and had been Prime Warden of a City Company, the Ironmongers. During a quiet interval in 1916 he, with Colonel H. E. R. James, carried out excavations at Chatby, near Alexandria. They discovered hundreds of objects of the early Ptolemaic period and reported the findings in the *Bulletin de la Société d'Archéologie*. In the Alps he was fond of hunting chamois, a gregarious animal resembling the antelope. Of this sport he wrote in the *Alpine Journal* and in *British Sports and Sportsmen*. He often went on holiday with his friend Sir Robert Jones, who said of him: "He loved the Alps and more especially the peaks of the Austrian Tyrol in chase of chamoix. His experiences of such adventures were always brilliantly recorded. For many years we shared a shoot in Prussia in the midst of deer and wild boar and stayed with a mutual friend and landowner, Robert Tudor. Many a winter evening we spent in close intimacy by the fireside listening with delight to Alfred Tubby on the habits of animals and his experience of travel."

Tubby was the recipient of many honours. He was joint founder in 1901 of the Society for the Study of Disease in Children which later became a section of the Royal Society of Medicine. He was president of this section in 1912. He was also president of the Section of Diseases of Children at the Annual Meeting of the British Medical Association at Exeter in 1907 and of the Joint Section of Orthopaedics and Diseases of Children at Newcastle in 1921. In 1912 he was president of the Hunterian Society and as Orator took "The Surgery of Paralysis" as his subject. He was Corresponding Member of the American Orthopaedic Association and an honorary member of several French scientific societies. In 1915 he was

awarded the gold medal of the first class from Accademia Fisico-Chemica Italiana for distinction in Science and the Hamanities. In 1924 he was elected a Fellow of the Society of Antiquaries. He returned from Egypt with two war decorations, one the Companion of the Bath and the other Companion of St Michael and St George. He died at Hastings on February 23, 1930.

He was about medium height, broad-shouldered and of distinguished appearance, his complexion slightly sallow, with pleasant blue-grey eyes that lent some attraction to his personality. He was an excellent conversationalist, his voice low-pitched and friendly. He married in 1890 Beatrice, the second daughter of William Payne of the Chamber of London. He had one daughter.

Alfred Tubby was old enough to be familiar with the traditions of pre-antiseptic surgery and young enough to embrace the teaching of Lister. He was therefore well placed to hand on a written account of what was of permanent value in the teaching of the early pioneers and yet well qualified to lead in the advance, under antiseptic precautions, of open operative correction of deformity. Furthermore he stood firm by the definition of orthopaedic surgery as the surgery of the entire locomotor system. By his incomparable text-book of 1912 he helped to raise the prestige of British Orthopaedic Surgery.

ARTHUR ROCYN JONES.

I acknowledge with gratitude the help given me by Dr W. Gordon Sears, M.R.C.P., to whom we are indebted for the portrait of his relative, Mr Tubby.

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PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION

ANNUAL MEETING 1952

The Annual Meeting of the British Orthopaedic Association was held in Sheffield on October 24 and 25, 1952, under the presidency of Sir Reginald Watson-Jones.

Increase of the water content of the nucleus pulposus as a factor in the development of low back pain and sciatica—*Mr A. Naylor* (Bradford) had studied experimentally changes in the pressure within the isolated intervertebral disc, excised with the bony end-plates, during immersion. Normal discs immersed in water showed an initial slight fall of pressure (ascribed to swelling of the annulus fibrosus with consequent separation of the end-plates), followed by a substantial increase due to swelling of the nucleus, which reached its maximum at fifteen hours; immersion in normal saline caused swelling of smaller degree. These pressure changes were not observed in degenerate discs. Further experiments suggested that the fluid entered the nucleus through the bony end-plates, which behaved much like a semi-permeable membrane. Absorption of fluid by the nucleus pulposus in the living subject might result from depolymerisation of the polysaccharides of the nucleus, with consequent reduction of the size of the particles and increase of osmotic power. *Mr Naylor* believed that changes in the water content of the nucleus pulposus might play an important part in the causation of back pain and that when the annulus fibrosus was thin or damaged, swelling of the nucleus from increase of water content might precipitate herniation.

Episodicity in the lumbar disc lesion syndrome—*Mr J. R. Armstrong* (London) recalled that one of the cardinal features of the symptoms of protruded intervertebral discs was their episodicity, the symptoms subsiding and recurring, sometimes repeatedly, at varying intervals. He discussed the pathological and mechanical factors in the disc and disc-root relationship that might account for these periodic variations. He had found evidence of at least twelve such factors, any one of which might operate in an individual case. 1) Final rupture of the annulus might occur suddenly from mechanical forces, and cause marked exacerbation of symptoms. 2) A nuclear fragment might become impacted and cause "locking" of the joint. 3) The size of a nuclear protrusion sometimes varied during movements and changes of position of the spinal column. 4) An existing tear of the annulus might extend, or might heal. 5) Oedema added to the size of a nuclear protrusion in its early stages; subsidence of this oedema would lead to decrease of symptoms. Oedema might also affect the nerve root. 6) Gradual shrinkage of a protruded nucleus led to spontaneous decrease of symptoms. 7) A nerve root might become adapted to stretching. 8) Relationship between nerve root and protrusion might vary. 9) A nerve root might, possibly, become elongated. 10) A nerve root often became adherent, with consequent pain when the nerve was stretched by changes of posture. 11) Permanent pathological changes might occur gradually within the nerve root itself. 12) In the stage of degenerative arthritis sudden exacerbations resulted from irritability of the intervertebral joint.

The treatment of lumbar intervertebral derangements by traction—*Dr E. J. Crisp* (London) said that although some years ago he was sceptical of manipulation in the treatment of intervertebral derangements, he had found that many patients were relieved, often dramatically, by sustained traction. He had designed an apparatus to exert traction on the lumbar spine without pulling upon the thorax or limbs. Traction up to 120 lb. was applied, without anaesthesia, usually for fifteen minutes. Careful measurements had shown that distraction of the spine did, in fact, occur. In a series of over two hundred patients treated in this way the results had been gratifying. Fifteen out of seventeen patients with acute lumbago, nine out of twelve with acute sciatica, and two out of six with pain after laminectomy, were completely relieved; 50 per cent of women with chronic back pain were improved. Experience had led him to believe that by no means all back pain or sciatica was due to prolapsed intervertebral disc. In many cases changes in the posterior joints, such as nipping of synovium between the facets, might be responsible. These were the cases that might be expected to respond well to non-operative treatment.

Sir Reginald Watson-Jones (London) said that the three preceding papers were of great and stimulating interest as representing respectively the experimental, the clinical and the empirical approach. He questioned the significance of experiments in which the intervertebral discs were immersed in water rather than in physiological saline. *Mr Philip Wiles* (London) said that he had practised manipulation in the treatment of patients with back pain and sciatica, at first with, but more recently without, anaesthesia. He thought that the dangers had been exaggerated. In only two cases had he precipitated an attack of acute sciatica, in each case, he thought, by hyperextension, which he now omitted from his routine. He agreed with Dr Crisp that in many cases of back pain the underlying pathology was not directly concerned with the intervertebral disc. *Professor B. L. McFarland* (Liverpool) thought that both forced flexion and forced extension were dangerous, and should be avoided. Traction might relieve about 25 per cent of patients with clinically doubtful disc lesions. *Mr Norman Capener* (Exeter) recalled that Putti had recommended traction, except in acute sciatica, as an adjunct to treatment of back pain. *Mr John Charnley* (Manchester) drew attention to the unique structure of intervertebral discs. The nucleus consisted almost entirely of acellular matter, which behaved almost like a chemical substance; thus, it could be dried and subsequently restored almost to normal by immersion. He believed that many pains in the back might be due to temporary pressure changes in discs.

Aids in the movement of direct skin flaps and tube pedicles—*Mr Wilfred Hynes* (Sheffield) described the management of three difficulties that were commonly experienced in skin grafting by flaps and tube pedicles. One important difficulty was the length of time occupied in the various stages of transfering a flap—often about three months in all. By a special test which indicated the degree of vascularisation at the pedicle of the flap, he had found it possible to reduce the waiting time between stages, sometimes to less than half that previously thought necessary. In this test atropine ($\frac{1}{75}$ of a grain) was injected into the flap after clamping the pedicle to be divided. If the effects of atropinisation (tachycardia and dry mouth) were observed within forty minutes, the pedicle could be divided safely. Another difficulty was to decide how much additional time should be allowed for revascularisation when part of the inset was lost by necrosis. Here again the atropine test gave a good indication of the viability of the flap, and it had shown that the blood-flow through a pedicle might be surprisingly good despite necrosis of a considerable part of its area. A third serious difficulty was that of "blue flap," a condition in which, within a few minutes of the operation, cyanosis began to appear around the inset of a flap, and was followed by necrosis which gradually spread and might involve loss of the whole flap. This complication was due to thrombosis of vessels in the flap, the capillary pressure being sufficient to drive blood in, but not to expel it. He had found that if the blood was kept moving in and out of the flap, thrombosis might be prevented or minimised. This could be achieved in some cases by altering the posture of the patient every ten minutes so that blood flowed in and out of the flap by gravity; or by intermittent venous occlusion by a pneumatic cuff applied to the limb proximal to the flap.

Mr I. L. Dick (Edinburgh) emphasised the importance of close co-operation between orthopaedic surgeon and plastic surgeon. He considered that split-skin grafting could be safely undertaken by the orthopaedic surgeon, but the transfer of flaps and tubes should be left to those specially trained in plastic surgery.

Early treatment of the bladder in paraplegia—*Mr A. G. Hardy* (Sheffield) emphasised that the problems of paraplegia must be regarded as a whole rather than individually. Thus, successful management of the bladder was closely related to the efficient prevention of sores, sepsis and prolonged immobility, all of which reacted unfavourably upon the urinary system. Exceptional care in nursing was essential, and diet should include high fluid intake. Management of the bladder should be designed not only to prevent complications, but also to encourage co-ordinated reflex activity, which often took a long time to develop and was dependent upon an intact lower segment of the cord. The method favoured was constant drainage through a urethral catheter of the balloon-retaining type, changed weekly with strict aseptic technique. Drainage was into a bottle beneath the bed except when the tube was clipped for retraining reflex activity. Irrigation was carried out by the closed method. Antibiotics were used as required, but infection was gauged more by clinical evidence than from bacteriological reports. The residual urine was carefully observed and each week the catheter was left out for a trial period to assess the progress of reflex activity. The duration of catheter drainage varied, being longest after complete transection in the lumbar region; it had never been required for more than thirty-two weeks. In forty-five cases of paraplegia treated from an early stage, fourteen patients had regained voluntary control; fourteen had uncontrolled reflex action; two had partly controlled reflex action; ten had controlled autonomous action; and five had uncontrolled autonomous action.

Surgical treatment of Dupuytren's contracture—*Mr H. J. Richards* (Oswestry) described the surgical treatment of Dupuytren's contracture. He recommended excision of the whole palmar

fascia by a painstaking technique. The incisions should be placed in the skin creases with, in the fingers, mid-lateral extensions. He emphasised that in the typical Dupuytren's contracture there was no actual loss of skin, but simply shrinkage secondary to contracture of the underlying fascia. Once the fascia was removed the skin would stretch if given time. Skin grafts or "Z" and "VY" incisions had not been necessary. In excising fascia it was important that the vertical prolongations should be included. Capsulotomy in an attempt to overcome fixed joint contractures was not advised. After operation a firm, massive pressure dressing was applied to the palm and the hand was rested in a posterior plaster shell, no attempt being made at that stage to overcome the original deformity. The sutures were removed on the fourteenth day and when the wound was fully healed active extension of the fingers was begun. Correction of the deformity was a gradual process, sometimes occupying many weeks or months. The results in fifty-seven cases were satisfactory and compared very favourably with those of fasciotomy (after which deformity invariably recurred), and of local excision of fascia (after which 60 per cent had recurred and only 20 per cent regained normal function). *Mr J. I. P. James* (London) confirmed from his own experience of a similar operation that skin grafting was unnecessary.

Supracondylar-Y fractures of the humerus—*Mr E. Mervyn Evans* (Swansea) recalled that in this fracture the olecranon was forced upwards between the humeral condyles. The injury was usually one of adolescents or young adults. Treatment was difficult because the fragments were unstable. Full operative reduction and internal fixation had given disappointing results because of consequent elbow stiffness. Because of this, many surgeons resorted entirely to conservative treatment, which, on the whole, gave better results than full operative reduction. Mr Evans suggested a simpler operative approach to the problem by which the fracture was converted into an ordinary supracondylar fracture, the management of which was relatively simple. His method was to fix the medial and lateral condyles rigidly together by a transverse screw inserted usually from the medial side, with minimal disturbance of the muscles and joint capsule. Thereafter the supracondylar fracture was reduced by manipulation and immobilised in plaster in the usual way. This limited operation appeared much less likely to jeopardise joint movement than the more extensive reconstructions formerly employed. It had given good results in six young patients. Conservative treatment was, however, probably preferable in old patients. *Mr O. J. Vaughan-Jackson* (London) thought that the principle of this modified operation was sound. He had tried a similar method with encouraging results. *Professor B. L. McFarland* (Liverpool) thought that it would be possible to show equally good results in a series treated with forearm traction in a Thomas's splint. *Sir Reginald Watson-Jones* (London) said that whereas he was sure that full operative reconstruction and internal fixation was the worst treatment, this modified operation was attractive and should be given a trial.

Primary internal fixation of compound fractures—*Mr F. R. Zadik* (Wigan) said that in closed fractures that were unstable the value of internal fixation was accepted, but that the principle of primary internal fixation of compound fractures was controversial. He believed that many advantages accrued from primary internal fixation provided the wound did not break down. Wound break-down was caused either by infection, or by tension; infection could be prevented by careful and radical excision of non-viable tissues, and by the use of antibiotics. He had employed primary internal fixation in twenty-four open fractures in which the fragments appeared unstable (tibia and fibula thirteen, ankle three, radius and ulna eight). Nineteen wounds healed by first intention; four broke down, three from tension, one from infection; one wound was not closed completely. His results showed that union occurred in an average time not significantly longer than that for simple fractures.

In a lively discussion *Mr Norman Roberts* (Liverpool) said that he did not accept the necessity for internal fixation of tibial fractures even in closed injuries. If it was accepted for simple fractures, he saw no objection to extending it to open fractures. *Mr C. H. Cullen* (Wigan) accepted the advantages of internal fixation for tibial fractures and thought that Mr Zadik had shown it to be safe in open fractures. *Mr H. Osmond-Clarke* (London) deplored the routine use of internal fixation for all fractures, but thought that every fracture should be treated on its merits. Many unfortunate results of internal fixation of open fractures had been seen during the war. *Mr Philip Wiles* (London) emphasised the danger to the limb if aseptic precautions were unsuccessful and the wound broke down. *Mr T. J. Fairbank* (Cambridge) thought that the problem rested on the outlook for healing of the wound as judged from the surgeon's experience. If it seemed certain that primary healing could be obtained, internal fixation was justified. *Mr J. N. Wilson* (Cardiff) thought that the method was justified in selected cases. *Sir Harry Platt* (Manchester) recalled that the problem had arisen repeatedly. Internal fixation of open fractures had been tried many times in the past and recurrently condemned. He accepted the justification for it in certain selected cases. *Mr J. C. Scott* (Oxford) agreed that much depended upon the likelihood of healing of the wound, which was the

matter for prime consideration. Only exceptionally was internal fixation justified at the stage when the wound was open. *Mr O. J. Vaughan-Jackson* (London) suggested that the practice might become more hazardous in the future because of the increasing incidence of resistant organisms. *Sir Reginald Watson-Jones*, summing up, said that in his view the wisdom of internal fixation depended upon the nature of the wound and of the fracture. If the wound was grossly contaminated the addition of further foreign material was quite unjustified. On the other hand, if the wound was such that primary healing, with suitable management, seemed certain, there could be no harm in internal fixation of the fracture if it was advisable on mechanical grounds. *Mr F. R. Zadik*, closing, said that most of the fractures on which he had based his paper were relatively slightly contaminated. His object had been to show that an unstable open fracture could be treated by internal fixation almost as safely as could a simple fracture.

The management of dislocations of the hip associated with fractures of the acetabulum—*Mr E. A. Nicoll* (Mansfield) reported observations from a study of 144 cases of dislocation of the hip joint, contributed by a number of surgeons forming a clinical research group of the British Orthopaedic Association. (A previous paper from the same source was read at the July 1952 meeting of the Association and reported in the August issue of the Journal, page 503). The association of a fracture of the acetabulum with traumatic dislocation might have three effects: 1) it might cause instability of reduction; 2) a fragment of bone might be included within the joint; 3) the incidence of late osteoarthritis, and of sciatic nerve lesions, was increased. Instability was likely only when a large segment of the acetabulum was displaced. Treatment should be by immediate operative reduction and fixation by a screw. The Kocher approach was used, gluteus medius and minimus being turned upwards to reveal the fragment. Inclusion of a fragment within the joint was exceptional, and occurred only with small fragments. Sciatic palsy was three times as common after fracture-dislocation as it was after simple dislocation. In four out of five cases the nerve lesion was incomplete, affecting almost invariably the peroneal fibres; the lesion was always in continuity, but the prognosis for recovery was poor (five out of thirteen in the series studied).

Sir Reginald Watson-Jones (London) emphasised the importance of immediate reduction of displaced acetabular fragments in cases of sciatic nerve palsy; the nerve was usually stretched over the sharp margin of the tilted bone and recovery was jeopardised by delay in reduction.

Some biochemical problems of bone—*Professor H. A. Krebs* (Sheffield) said that whereas early studies of bone were concerned with its composition, more recent research had been directed towards a study of its activity. Investigations in which radioactive isotopes serving as " labelled " molecules were introduced into the body, had shown that bone, in common with other living tissues, was in a " dynamic state "—that is, the material that formed its structure was constantly being changed. In normal circumstances removal and resynthesis proceeded at the same speed so that there was no apparent change in structural composition. The rate of the exchange varied with different tissues, being relatively rapid in those with high metabolism: thus, in the liver some constituents had been shown to be replaced completely within a matter of days. In bone, animal experiments had shown that about 30 per cent of the phosphorus was replaced in fifty days, but the rate was different in different parts of the bone. Any explanation of the significance of the dynamic state of living tissues was, so far, only hypothetical. Professor Krebs thought it possible, however, that the dynamic state was related to excitability—that is, the capacity of a tissue to react to altered circumstances such as those of a changed environment. Cells might depend for their viability upon this capacity to react to changed conditions, and it seemed likely that they would be unable to react unless in a dynamic state.

Osteoid osteoma—*Mr D. Wainwright* (Newcastle) reported seven cases, five proved histologically. All were males between ten and twenty years of age, and the bones affected were: tibia three, fibula one, neck of femur one, ulna one, coccyx one. He emphasised that in some cases careful clinical and radiological study was necessary to detect the lesion.

Injuries to the lower tendon of biceps brachii—*Mr G. G. Farrington* (London) reviewed three cases of rupture of the biceps mechanism at its lower end. In the first case, that of a young, athletic man, the tendon was avulsed from the radial tuberosity; there was moderate disability, especially in such activities as handling a tennis racket. After suture of the tendon to that of brachialis anterior, good function was restored and there was no obvious loss of supination power. In the second case, again in a robust young man, there was moderate disability, but operation had not yet been undertaken. In the third case, that of an elderly man, the ruptured ends were found frayed. Fair recovery followed suture of the proximal end of the tendon to brachialis anterior. Study of the literature suggested that the injury was usually an avulsion at the insertion of the tendon rather than rupture of the tendon itself. The accident usually followed heavy use of the arm, and was diagnosed by absence of the tense biceps tendon which is normally readily palpable.

In the past, attempts had been made to restore the original attachment of the tendon to the radius, but this was hardly practicable, and potentially dangerous. Suture of the tendon to brachialis anterior was simple, and in his experience gave satisfactory results.

Tuberculosis of the elbow—*Mr J. N. Wilson* (Cardiff) reviewed thirty-one cases of tuberculosis of the elbow joint. The greatest incidence was between ten and thirty years. He recognised four types: synovial, extra-articular, coronoid and massive. The massive type was the most common. Sinuses and tuberculous lesions elsewhere were common complications. In one case late ulnar paresis followed involvement of the medial humeral condyle. Treatment in most cases had been conservative: the joint was immobilised in plaster for an average of eighteen months. Streptomycin had been available for only four cases, in which it seemed to help resolution. When the disease was quiescent the elbow was suitable for light work without support, but if heavy work was demanded a block leather splint was supplied. Arthrodesis had been undertaken in three cases on account of persistent pain or recurrent flares. Three further elbows, all with sinuses, underwent spontaneous bony fusion. Some rotation of the forearm might be retained when the humero-ulnar joint was fused. An angle of 120 degrees was often the position of choice for arthrodesis in working men.

Lengthening of the gastrocnemius tendon in cases of spastic equinus deformity—*Mr G. A. Pollock* (Edinburgh) recalled that in cases of spastic diplegia the commonest deformity requiring operative correction was equinus. Recurrence after operation was frequent and might be due to inadequate lengthening, to lengthening of the whole tendon when the contraction was in the gastrocnemius component, or to inadequate splintage after operation. When the contraction was confined to the gastrocnemius component of the calf group, as determined by the knee flexion test, lengthening of the affected tendon alone was satisfactory; it gave the advantages of attacking the trouble at its primary site, of preserving the strength of the calf muscles and of avoiding risk of later calcaneus deformity. The technique of the operation was illustrated by a film.

Clinical Demonstrations

The early treatment of fracture-dislocation of the thoraco-lumbar spine complicated by paraplegia—*Mr F. W. Holdsworth* and *Dr A. G. Hardy* (Sheffield) described and demonstrated in detail their routine examination of patients with fracture-dislocation of the thoraco-lumbar spine with paraplegia, and showed how, from simple clinical tests and radiographs, the upper limit of the lesion, the condition of the nerve roots and the condition of the distal segment of the cord could be accurately analysed. They emphasised the importance of reflex function, especially the bulbo-cavernosus and the anal skin reflex, in indicating reflex activity in the distal part of the cord. The technique of nursing, by which fifty cases had been successfully treated without a pressure sore developing, was demonstrated. If the fracture was unstable operative fixation was undertaken immediately. Thereafter the patient was nursed on pillows and was turned methodically every two hours. Patients were shown with fracture-dislocations at the D.12 to L.2 level illustrating: 1) complete cord lesion and complete root lesion; 2) complete cord lesion with partial root escape; and 3) complete cord lesion with total root escape. The function and gait that could be hoped for in patients in each group were shown. The impressive results emphasised the importance of segregation of paraplegic patients in special centres equipped and staffed for their proper care.

Miscellaneous cases—*Mr Alford Dornan* (Sheffield) showed examples of pectoralis major transplants for paralysis of the elbow flexors. The results were particularly good when the pectoralis major muscle was well developed. *Mr S. Pappworth* (Sheffield) illustrated results of treatment of acute osteomyelitis by conservative treatment, antibiotics and aspiration when indicated by increasing size of an abscess in the soft tissues. He preferred to avoid operation which, in his opinion, was liable to lead to unstable scars and recurrent sinus formation. He claimed 200 cases without death, sinuses or scars. *Mr G. Gordon* (Sheffield) discussed the etiology of congenital pseudarthrosis of the tibia and showed cases. Development, he said, was governed by genetic and environmental factors. Mechanical factors, such as uterine pressure, may cause deformity in certain circumstances. He suggested that abnormal anterior bowing of the tibia was due to uterine moulding, possibly favoured by disproportion between uterus and foetus. The tibia might bend at a time when it was weakened by degeneration of the cartilage cells that occurred before the early formation of bone was established.

1953 MEETINGS

The spring meeting of the Association will be held in Dublin on April 23, 24 and 25. The annual meeting will be held in Birmingham on October 23 and 24.

ROYAL COLLEGE OF SURGEONS OF EDINBURGH

CONFERMENT OF HONORARY FELLOWSHIP

On November 5, 1952, the Honorary Fellowship of the Royal College of Surgeons of Edinburgh was conferred upon Sir Reginald Watson-Jones. He is shown here being presented by Mr Robert I. Stirling to the President of the College, Professor Walter Mercer, who is supported on his left by the Reverend Dr Charles L. Warr, Chaplain to the College, and Mr J. J. Mason Brown, Secretary of the College.

UNIVERSITY OF LIVERPOOL

HUGH OWEN THOMAS MEMORIAL LECTURE

The influence of Hugh Owen Thomas on the evolution of the treatment of skeletal tuberculosis—Mr Arthur Rocyn Jones delivered the Hugh Owen Thomas Memorial Lecture on November 13, 1952, at the Liverpool Medical Institution.

Having shown Hugh Owen Thomas as an outstanding pioneer in orthopaedic surgery, the lecturer described how in pursuit of his work Thomas found it necessary to have an orthopaedic clinic, a small hospital and a workshop; in this establishment one might see in embryo the pattern of the modern orthopaedic hospital. The study of skeletal tuberculosis was one of Thomas's main interests in life, and in its treatment he had two guiding principles: first, that many patients exhibited an inherent tendency to recovery; and secondly, that patient and morbid part required rest. The lecturer indicated how Thomas applied his principles and how he carried out his methods, how he made his splints and how he proved the efficacy of prolonged immobilisation.

The re-introduction of operative methods was then traced up to the present. Techniques in arthrodesis of the hip and in operation on the spine, either to relieve paraplegia or to secure fusion, and a most interesting method of localising any particular vertebra, were described and illustrated.

Finally the importance of regarding tuberculous disease as systemic and the use of more recent antibiotics were interestingly described. The lecture was delightfully illustrated by lantern slides and will later be published.

UNIVERSITY OF OXFORD

FORTHCOMING LECTURES AT THE NUFFIELD ORTHOPAEDIC CENTRE

Lectures to be delivered at the Wingfield-Morris Orthopaedic Hospital during the Hilary Term include the following. *February* 12—Colonial Medicine, by Mr H. J. Seddon; *February* 26—Current views on the etiological and therapeutic problems of the chronic rheumatic diseases, by Dr A. G. S. Hill; *March* 12—Symposium on poliomyelitis, introduced by Professor J. Trueta.

ROYAL SOCIETY OF MEDICINE

SECTION OF ORTHOPAEDICS

Clinical meeting—The Orthopaedic Section held a Clinical Meeting on October 7, 1952, with the president, Mr H. Jackson Burrows, in the chair.

Arthroplasty of the hip in amputation stumps—*Mr L. Gillis* (Roehampton) presented several patients in whom a painful thigh stump had been attributed to degenerative arthritis of the hip and was controlled by an arthroplasty. The artificial limb allowed early walking by relieving the new joint from weight.

Acrylic replacement in fractured phalanx—*Mr F. G. Ward* (Staines) had used an acrylic insert to replace the proximal half of a fractured phalanx having a disorganised articular surface. His patient, aged thirty-one, had recovered an apparently normal finger after three months and maintained the function six months later. The great success in this case gave hope of a better outlook in this commonly disabling injury.

Tuberculous arthritis treated by antibiotics and early arthrotomy—*Mr M. C. Wilkinson* (Black Notley) showed good immediate results in early tuberculosis of the hip and shoulder after treatment by antibiotics and early arthrotomy with removal of some synovial membrane and of any radiographically ischaemic bone. He was warmly supported in emphasising that early surgery was only an adjunct to the full sanitorium régime.

Fanconi's syndrome—*Mr M. Singer* (London) presented a case in which massive calciferol treatment led not only to relief of the rickets but also to disappearance of the amino-aciduria. Subsequent osteotomies for the leg deformities united normally. Some other members reported less successful osteotomies, which they agreed should not be carried out while any florid rachitic signs remained.

Joints disorganised by acute septic arthritis of infancy—*Mr G. H. Bedbrook* (Croydon) showed a boy of six years in whom acute septic arthritis of early infancy (Smith, Thomas: St Bartholomew's Hospital Reports, 1874, **10,** 189) had caused gross disorganisation of the right hip and left knee. The child was exceedingly active and it was generally agreed that no treatment should be given at present.

Other cases shown included: chondro-osteo-dystrophy, with general platyspondylitis but no diminutive vertebra, by *Mr G. G. Farrington* (Harrow); osteopoikilosis, well documented and to be published in full, by *Mr G. R. Fisk* (Sawbridgeworth); ankylosing spondylitis in a woman, bedridden for three years and now able to walk after osteotomy of the spine and arthroplasty of one hip, by *Mr A. G. Cronin* (London); two cases illustrating the difficulty of diagnosis between bone sarcoma and bone infection and the importance of adequate biopsy, by *Mr D. L. Evans* (London); and a case of atypical degenerative arthritis of the hips in a man of thirty-one and not suitable for arthroplasty, by *Mr H. E. Harding* (London).

Announcement of special meeting—*Dr Henry L. Jaffe*, of the Hospital for Joint Diseases, New York, has accepted an invitation to address the Orthopaedic Section of the Royal Society of Medicine on osteoid-osteoma, on June 8, 1953. He has also agreed to conduct a conference at the Institute of Orthopaedics on Benignancy and Malignancy in Cartilaginous Tumours on June 10, and will deliver a Moynihan Lecture at the Royal College of Surgeons on June 9. He will fulfil several other engagements during his stay, including the conduct of a slide seminar before the beginning of the meeting of the Pathological Society in Belfast on June 2.

THE BONE AND TOOTH SOCIETY

A meeting of the Bone and Tooth Society was held at the Institute of Orthopaedics on October 16, 1952, with Professor W. D. Newcomb in the chair. A symposium was presented on the technical methods used in bone and tooth investigations.

Methods of preparation of tissues—*Dr P. H. Staple* approached the subject from the general aspect of preparing any tissues for histochemical examination, which raised many points relevant to the special problems of hard tissues. Preparation of tissues began with the management of the subject yielding them: anaesthetics and cyclical variations in biochemical processes sometimes affected histochemical investigations. The manipulations of tissues before histochemical reactions might invalidate results. Problems inherent in present methods of microtomy were discussed. Methods of fixation were compared and illustrations were shown of similar specimens treated by chemical fixation and by freeze drying procedures. The development of more physiological methods for demineralisation was suggested.

Histochemical methods applied to bone—*Dr A. G. E. Pearse* described how the application of histochemical methods had been discouraged by purely technical difficulties, so that the volume of reported work was small. Interest was largely directed towards three particular fields, the

demonstration of inorganic materials, the qualities of the matrix protein and the localisation of enzymes. Histochemical methods for inorganic materials had contributed little to our knowledge of the structure of bone and therefore little was said about them. In the second field important work had been done on the metachromatic staining of cartilage and bone matrix and its significance; this was discussed. It was in the third field that most work had been done on alkaline phosphatase and its relationship to calcification. The older methods for alkaline phosphatase had many defects; some newer methods for this enzyme (and for acid phosphatases and non-specific esterases) were demonstrated, and their impact on the various theories of bone formation were discussed.

The infra-red spectra of collagen and ossified tissue—*Dr W. C. Price* gave an account of the theory and technique of infra-red spectroscopy and its application in identifying chemical groupings both organic and inorganic. The use of the reflecting microscope with polarised radiation to decide between different postulated structures of fibres was illustrated with reference to collagen. Infra-red spectra of powdered bone and ossifying tendon were exhibited. They showed the collagen together with the spectra of the phosphate and carbonate ions. The strongest bands were due to the phosphate ions; those of the carbonate were very weak. The strength of the phosphate bands indicated that they could be used to follow the early stages of calcification in a tendon.

Radiological investigations—*Dr J. Theulis* showed how the information that was obtained by the radiological examination of bones and teeth depended on the technique adopted. On the one hand, x-ray diffraction patterns enabled the nature of the inorganic salts to be determined and the arrangement of the histological sub-units to be examined. On the other hand, radiographic examination could lead to the determination of the degree of calcification in the various tissues. The principles involved in x-ray diffraction were explained and a typical cylindrical camera for use with "monochromatic" x-rays was shown, together with a flat-plate or transmission camera used for the determination of the arrangement of the individual crystallites of the inorganic material. Finally, an account was given of the way in which, by the microphotometric examination of "monochromatic" radiographs prepared from uniform sections, the degree of calcification in calcified tissues can be estimated to within a few per cent and measured from point to point. An autoradiograph was also shown which was obtained by exposing a tooth section in the large Harwell Pile (BEPO) and recording photographically the β-radiation from the radioactive phosphorus.

Autoradiography—*Dr Janet M. Vaughan* described how the autoradiography of bone was complicated by the difficulty of cutting thin undecalcified sections. Two types of autoradiographs were required for the proper understanding of the behaviour of different isotopes: 1) the geographic autoradiograph prepared from relatively thick sections of a whole bone (100–200μ), and 2) the histological autoradiograph prepared from thin sections of small pieces of bone (5–10μ). Methods of preparing geographical autoradiographs were described and some illustrations given of what could be learnt from such autoradiographs based on work with Sr89, Sr90 and Y91. It was suggested that even this crude technique was a valuable tool for studying the physiology of bone. It was essential for an estimation of possible hazards from bone-seeking isotopes. The preparation of histological autoradiographs was still in an experimental stage and was not discussed in detail.

LIVERPOOL MEDICAL INSTITUTION

POSTGRADUATE LECTURE

A lecture on congenital dislocation of the hip was given to postgraduate students of orthopaedic and general surgery in Liverpool on June 23, 1952, by Gunnar Wiberg, Professor of Orthopaedics at the University of Lund, Sweden.

Professor Wiberg said that although functional results were often better than the radiographic appearances suggested and must therefore be the ultimate test, an apparently good radiographic reduction was no guarantee of good function, and it was of value to use "geometrical" figures in assessing (or comparing) radiographic appearances. The "C.E. angle" was the name Professor Wiberg gave to the angle formed at the centre of the femoral head by two lines (the centre of the head is determined by a special projector). One line is the vertical, the other is drawn from edge to edge of the acetabulum—like a ruler resting across the top of a bowl. In adults a C.E. angle of 25 degrees or more is normal, 25–20 degrees is equivocal, and less than 20 degrees indicates "mal-development" or "dysplasia." In children a C.E. angle of 20 degrees upwards is normal, and 15 degrees downwards is dysplastic. With low C.E. angles dislocation or subluxation may recur.

Professor Wiberg next dealt with the accessory ossicles in the capsule or at the lip of the acetabulum. He found that they occurred in 52 per cent of hips after reduction of congenital dislocation, and they appeared early—that is, at eight to ten years of age. In ordinary hips these ossicles appeared between eleven and seventeen years of age, and only in twenty-three out of 632 hips (less than 4 per cent). He found that a reduced congenitally dislocated hip in which the

ossicles occurred was twice as likely to develop a normal C.E. angle as a hip in which the ossicles did not appear.

Finally, Professor Wiberg discussed the "shelf" operation and the technical difficulties. He advocated its performance as early as indications were definite. Mere dysplasia was not a sufficient indication. But if the child was, say, eight years of age, he would make a shelf "high" without reducing the hip. To the shelf could be added a rotation osteotomy if tendency towards dislocation persisted.

REGIONAL ORTHOPAEDIC CLUBS

SOUTH-WEST ORTHOPAEDIC CLUB

The South-West Orthopaedic Club met at Winford Orthopaedic Hospital on November 22 under the chairmanship of Mr A. Eyre-Brook. In the morning the forty-five members present split into three groups and were taken on ward rounds by members of the staff of the hospital. Subjects demonstrated included reduction of congenital dislocation of the hip by traction and abduction in flexion on a "gallows" splint, and arthroplasty of the knee for osteoarthritis using nylon sheets (the result did not appear superior to that of simple synovectomy). After lunch a short business meeting was held and plans were formulated for a visit to Paris in the spring. The following were among the short papers presented.

Arthrodesis of the ankle—*Mr K. H. Pridie* reported a new method of arthrodesis of the ankle using a $1\frac{1}{2}$-inch auger bit. The joint was approached through a medial incision, the medial malleolus being removed with an osteotome. With the centre of the auger in the joint, a cavity was reamed out in the lower end of the tibia and upper surface of the talus. The cavity was filled with the bone chips removed by the reamer or, if the bone was very sclerotic, with iliac bone chips. Sometimes the remains of the medial malleolus were inserted as a key graft. It was possible to correct valgus or varus deformity easily as the ankle was "plastic." The operation had been done twelve times for various conditions but not for tuberculosis. Union was sound in about three months and there had been no failures.

Prolapsed intervertebral disc—*Mr McCormack* reviewed the correlation of the neurological signs and operative findings in fifty cases of prolapse of lumbar intervertebral discs. All patients had been subjected to the usual neurological examination before operation. Forty-two disc lesions were found, thirty-two at the lumbo-sacral joint and twelve at the L.4–5 joint (there were two double lesions). There were six negative explorations, and two patients were found to have other pathology. In one-third of cases the neurological signs were unhelpful or wrong in indicating level. In twenty-one of the thirty-two cases in which the lesion was situated at the L.–S. joint the ankle jerk was diminished or absent and in fifteen there was sensory loss in the distribution of the first sacral dermatome. The findings in association with the L.4–5 disc were less helpful. In no case in the series was the knee jerk impaired and a lesion of the L.3–4 disc was not encountered. In discussion, the general feeling emerged that if a definite lesion was found at the L.5–S.1 disc space, the L.4–5 space should not be explored as double disc lesions were rare and in any case this type of exploration was incomplete as a disc lesion might also be present on the opposite side. *Mr Pridie* stated that an excellent method of determining whether or not a disc was pathological was to inject it with saline. The normal disc would not take more than 1 cubic centimetre whereas an abnormal disc might absorb 2 cubic centimetres or more. *Mr Mervyn Evans* spoke of the difficulty in getting miners who had disc lesions back to work and said that the difficulty appeared to be directly related to the form in which compensation was paid: those with weekly payments seldom returned, whereas many of those with "lump sum" payments did so.

Chronic arthritis of hip—*Mr Keith Lucas* showed a case of chronic arthritis of the hip associated with changes in the hands, ankles and wrist suggestive of rheumatoid arthritis. The patient had been treated with gold, streptomycin and P.A.S. The course of the hip disease shown by serial radiographs strongly suggested tuberculous disease but there was no positive proof of this, and a synovial biopsy had not been done. He considered the other joint changes to be an allergic manifestation of a probable tuberculous infection. The consensus of opinion of the meeting was "not proven." *Mr F. Durbin* emphasised the importance of establishing the diagnosis before any patient was labelled tuberculous; there was a stigma attached to the disease and no person could be accepted by the services or for life assurance purposes with a past history of this trouble. It was possible that because streptomycin and chemotherapy cut short the course of tuberculosis many cases of non-tuberculous joint irritation might be presumed to be due to tuberculosis in the absence of positive evidence. He urged that synovial biopsy should be carried out if other means of diagnosis had failed. Other speakers mentioned the value of gland biopsy.

Fracture of head of radius—*Mr Fowler* reported three cases in which there had virtually been a traumatic excision of the head of the radius, the fragments being "exploded" through the

capsule into the extra-articular tissues. In such cases it was unnecessary to remove the fragments and indeed it was meddlesome to do so because a good result would ensue without operation. All these cases had about three-quarters of the normal range of flexion and extension and full rotation. *Mr J. Bastow* stated that this was an uncommon fracture confined to a late age group. *Mr Mervyn Evans* observed that the treatment of fractures about the elbow in old people should be conservative because any operation then leads to a poor result. The value of inserting an acrylic radial head when there was subluxation of the distal radio-ulnar joint was mentioned.

Complications of the treatment of club foot—*Mr K. H. Pridie*, opening a discussion, considered that all club feet were amenable to treatment and that failure was the fault of the surgeon. Treatment might be too active. He recognised the following types: 1) a positional deformity easily corrected; 2) a severe deformity correctable only with difficulty on account of considerable resistance; 3) deformity complicated by a paretic factor (poor results were to be expected); and 4) Volkmann's ischaemic contracture occurring perhaps as a result of treatment. He also mentioned the influence of heredity. Denis Browne believed that club foot was entirely fortuitous and positional but the evidence of Duraiswami on this point could not be discounted, nor could his own clinical experience of the familial incidence.

Mr Bastow emphasised that the complications were essentially those of treatment. During the first six weeks manipulation should be little and often, extreme gentleness being used. The soft tissues were frequently damaged by forcible manipulation—the skin was split, pressure sores were produced and Volkmann's ischaemic contracture could develop. He mentioned that Kite's plasters could sometimes produce severe circulatory trouble. Over-correction should only be obtained at the end of three months. Radiographs were shown demonstrating the bad effect of forcible manipulations over a long period on the growth of the lower tibial epiphysis and talus.

Other events—The Annual Dinner was held at the Spa Hotel, Bristol. Mr Eyre-Brook, after dinner, recounted the life history of Mr Hey Groves of Bristol, the pioneer orthopaedic surgeon of the South-West. Mr Pridie demonstrated many instruments used in bone surgery by Hey Groves, some of which were prototypes of instruments used by orthopaedic surgeons to-day. The most interesting was a four-flanged intramedullary nail made of steel. There was also an ivory prosthesis with a peg which closely resembled the modern acrylic prosthesis for the head of the femur.

EAST ANGLIAN ORTHOPAEDIC CLUB

A meeting of the East Anglian Orthopaedic Club was held on May 24, 1952, at the Norfolk and Norwich Hospital. Clinical cases were shown.

Küntscher nailing—*Mr Godfrey*, introduced by Mr McKee, showed two unusual cases treated by Küntscher nailing. The first was that of a man who had had a fracture at the junction of the middle and lowest thirds of the femur, first treated by plating. The plate bent at the site of fracture; it was removed and the fracture was stabilised by the insertion of a Küntscher nail. The other was the case of a woman of sixty-nine who had been a cripple for many years with bent legs. Four years ago she had a fracture of the femur which was plated and recently had another fracture below the plate. The plate was removed and the Küntscher nail was inserted through the femoral condyle as the gross bowing made the normal technique impossible. After fixing the fracture, the excess nail was cut off.

Arthroplasty of hip—*Mr Godfrey* demonstrated two cases of Judet-type arthroplasty of the hip carried out through a posterior route, which he maintained allowed for easier dislocation of the hip.

Volkmann's ischaemic contracture—*Mr Godfrey* showed a case of contracture complicating a fractured olecranon. An interesting discussion followed on the relative values of the Max Page operation and of repeated plasters.

Recurrent dislocation of shoulder—A case was demonstrated which had been treated by the Bankart operation with the capsular lesion fixed by stapling.

Genu valgum—*Mr Davidson*, introduced by Mr Howard, showed five cases of genu valgum treated with epiphysial staples. They showed gaps between the ankles up to 4½ inches before operation. The ages ranged from nine years to thirteen years and the staples were left in position for from seven months in the oldest child to two-and-a-half years in the youngest. A discussion on the ultimate fate of the epiphysis followed.

Pseudarthrosis of the tibia—*Mr Davidson* showed cases, one of which had been demonstrated at a previous meeting (1951). These showed that successful grafting could be carried out if the defective area could be bypassed adequately.

Rheumatoid arthritis—*Mr Davidson* presented a patient with rheumatoid arthritis with widespread gross deformity. He had been treated by bilateral arthrodesis of hips and excision of metacarpal heads of the three middle fingers. The patient was anxious to have the other hand

treated in the same way. He also had pain and stiffness in his shoulder and the possibility of the insertion of an acrylic head to the humerus was discussed.

Skin grafts—*Mr L. M. Rouillard*, introduced by Mr Brittain, demonstrated the value of full-thickness grafts over bare bone, joints or tendons, in cases of an extensive ankle injury in which he had placed a graft from the opposite thigh to cover the heel, a case of extensive burns of leg and a motor-cycle injury with a burn of the dorsum of the foot with destruction of tendons, and compound fractures of tibia and femur. Mr Brittain expressed the debt owed by orthopaedic surgeons to plastic surgeons and commented on the beautiful results of Mr Rouillard's work.

Repair of cut tendons—*Mr R. Howard* demonstrated the value of a palmaris longus graft for the repair of a cut flexor tendon of thumb and the repair of the flexors of the index finger by removal of the distal part of flexor sublimis and suture of both tendons to flexor profundus. In this instance he had also sutured the digital nerve successfully.

Arthrodesis of the hip—*Mr Howard* showed a case of a V-arthrodesis of the hip, demonstrating the great increase in the size of the graft.

Osteitis fibrosa cystica—*Mr Thorpe*, introduced by Mr McKee, showed a case of osteitis fibrosa cystica of parathyroid origin which showed calcification of the kidney tubules. Recalcification of the cysts occurred after parathyroidectomy. This was probably an example of Hawshaw-Christian syndrome.

Arthrodesis of hip by lag screw—*Mr G. K. McKee* showed patients with arthrodesis of the hip by the insertion of a lag screw, of which he had experience of forty cases. In some early cases the screws had broken but this difficulty had now been overcome. In no case had the screws worked loose. The technique had the advantages that there was no need for radiographic control, and that it was possible to avoid plaster fixation and to begin early activity.

Fractured scaphoid—*Mr McKee* showed a case of a fractured scaphoid treated by excision of the styloid process of the radius, which provided a graft for the scaphoid. The functional result was good but in discussion it was suggested that the removal of the radial styloid was the essential step in the relief of the patient's pain.

Supports for prolapsed intervertebral discs—*Mr McKee* demonstrated a form of support used by him in the treatment of patients with prolapsed intervertebral discs. This was a light metal frame covered with leather consisting of a moulded back support with three bands placed around the lower ribs, round the waist and round the pelvis. It was claimed that this was light, cool to wear and comfortable.

NORTH-EAST ORTHOPAEDIC CLUB

During the last three years a flourishing orthopaedic club has existed in the North-East of England. Under the chairmanship of Mr C. Gordon Irwin, meetings have been held at regular intervals at the Royal Victoria Infirmary, Newcastle upon Tyne. All the orthopaedic surgeons working in North Yorkshire, Durham, Northumberland and Cumberland are members of this group. They are enthusiastic attenders at the meetings as far as their hospital duties, the weather and their commitments allow. A start was made last session in holding meetings at other centres in the North-East and very shortly a joint meeting will be held in Edinburgh with the Edinburgh Orthopaedic Circle.

Generally speaking, the meetings have consisted in the presentation of cases or radiographs and in discussion. Rare and interesting cases have their place but in a widespread area such as the North of England, the most valuable contribution of the Club is the free discussion on difficult cases. In addition, these periodic meetings give an opportunity to members to talk about the orthopaedic problems particular to the North's mining and industrial communities. It is hoped to send regular reports on the future activities of the Club.

IRELAND

IRISH ORTHOPAEDIC CLUB

A meeting of the Irish Orthopaedic Club was held at Musgrave Park Hospital, Belfast, on December 6, 1952. The chairman was Professor Arthur Chance.

At the morning session, *Mr Martin* showed a series of cases of the end-result of arthrodesis of the hip joint by posterior ischio-femoral approach, using a femoral graft. He also showed a case of spinal osteotomy.

Mr Wilson showed a series of cases of slipped upper femoral epiphysis, and six cases of slipped upper humeral epiphysis.

Members of the club were entertained to lunch at the City Hospital, Mr Hall acting as host. In the afternoon, Mr Hall and Mr Withers demonstrated an interesting series of cases showing club foot deformity corrected by open operation on the soft tissues.

FRANCE

FRENCH SOCIETY OF ORTHOPAEDICS AND TRAUMATOLOGY

ANNUAL MEETING 1952

The twenty-seventh Annual Meeting of the French Society of Orthopaedics and Traumatology was held in Paris on October 2 and 3, 1952, under the presidency of Dr G. Huc. The meeting was attended by many surgeons from other countries. The two main subjects for discussion were the treatment of congenital club foot (opened by *Drs Cabanac, Petit* and *Maschas*, and Dupuytren's contracture (opened by *Mr James* and *Dr Tubiana*). A symposium was also presented on affections of the spinal canal, including papers on the development of the vertebral column (*Dr Tondury*, Zürich), the neurological complications of spinal deformities (*Dr Garcin*, Paris), the radiographic and tomographic study of the spinal canal (*Dr Fischgold*, Paris), and considerations of operative technique (*Dr Ricard*, Lyon). Among other presentations was an important discussion on the treatment of tuberculosis of bones and joints to which *Drs Gerard-Marchant, Allenbach, Etienne Sorrel* and *Kaufmann* contributed.

On the proposal of Professor Merle D'Aubigné a committee was appointed to study a system of recording joint movements which could be adopted by all orthopaedic surgeons in France and perhaps by those of other countries. The committee includes Professor Merle D'Aubigné, and Dr Descamps of France, with Dr Marino Succo (Italy), Dr Debrunner (Switzerland), Dr Marique (Belgium) and Dr Wouters (Holland).

Officers for 1953—Professor Ingelrans, of Lille, has been elected president; the vice-presidents are Dr Padovani (Paris) and Dr Salmon (Marseilles); and Dr Creyssel (Lyons) is a member of the committee.

Future subjects for discussion—Subjects for discussion in 1953 are: Idiopathic scoliosis (Drs Quenean and Stagnara), and the treatment of post-traumatic stiffness of the knee (Drs Ramadier and Lacherez). In 1954 the subjects for discussion will include the late results of the treatment of congenital dislocation of the hip in children under five (Dr Meary and Gourdon), and the bone bank (symposium introduced by Dr Jean Judet).

SWEDEN

ORTHOPAEDIC RESEARCH

Experimental arterial surgery—Dr Tor Hiertonin has carried out experimental work on the problem of restoring the continuity of arteries, severed by disease or injury, at the Orthopaedic Clinic of Caroline Institute, Stockholm. It was felt that indirect surgery (sympathectomy) in many cases of obliterative disease of arteries was not an adequate treatment and it was hoped that better results would follow a direct surgical approach (resection and replacement by a vascular graft). The work, published as *Supplementum* 10 of *Acta Orthopaedica Scandinavica* (1952) had the following purposes: 1) To investigate the tissue respiration of arterial segments preserved in nutrient medium. 2) To study the techniques of vascular surgery and to test homologous arterial transplantation by means of the reconstruction of experimental defects in the aorta and peripheral arteries. 3) To study the functional and morphological fate of such transplants. 4) To determine whether or not the length of time a vascular segment is preserved is related to the process of healing or to successful grafting. 5) To determine the tensile strength of the transplant, the anastomotic line and the host aorta.

Experimental defects in the abdominal aorta and in the femoral artery in dogs were bridged by homografts preserved in a nutrient medium. In regard to healing and function of these grafts the technique was of great importance; the viability of the inserted segments was less important. As vitality test the tissue respiration of the preserved segments was used, determined by Warburg method.

The author devised an arteriographic technique to test the distensibility of the transplants *in vivo*. Arteriograms performed in high and low blood pressure revealed that the graft was relatively stiff and did not conform to the contractions and dilations of the host vessel. The grafts were thus usually capable of performing the function of a pipeline but apparently did not have the capacity of functional dynamic adaption.

After the period of observation (up to sixteen months) a number of tensile-strength experiments were made on strips of the aortic wall in and beyond the area of operation. Load-deformation curves provided an explanation for the rigidity of the grafts shown in the arteriograms at different blood pressures. The tensile strength of the anastomoses compared favourably with that of the intact host aorta. The grafts themselves possessed a considerable tensile strength. The risk of

aneurysmal dilation or rupture therefore seemed to be small. The morphological fate of the transplants was illustrated step by step in the gradual degeneration of the graft and in the substitution of tissue from the host. In general there was no great difference in the histology of implanted respiring and non-respiring grafts. The author was of the opinion, however, that devitalised and dead vascular segments were somewhat less satisfactory.

If the procurement of material for a practical clinical blood vessel bank in Stockholm proves to be too difficult it will be necessary to use " non-respiring " segments (as well as other methods of storage: frozen or lyophilised segments).

YUGOSLAVIA

YUGOSLAV ORTHOPAEDIC INSTITUTES

The annual meeting of the orthopaedic surgeons of the Kraljevica, Rovinj and Biograd Orthopaedic Institutions will be held at Kraljevica from June 25–28, under the presidency of Dr Alexander Manzoni. The chief subjects for discussion are: 1) The operative treatment of congenital dislocation of the hip at every age of life; 2) osteoarthritis of the hip and its conservative and operative treatment; 3) tuberculous arthritis of the hip and its operative treatment; 4) antibiotics in the treatment of tuberculosis of bones and joints; 5) Climatic treatment of tuberculosis of bones and joints.

SOUTH AMERICA

SECOND CONGRESS OF THE LATIN-AMERICAN SOCIETY OF ORTHOPAEDICS AND TRAUMATOLOGY

The Second Congress of the Latin-American Society of Orthopaedics and Traumatology, combined with the tenth Congress of the Brazilian Society of Orthopaedics and Traumatology, will be held in Rio de Janeiro from July 19 to 26, 1953. There will be gathered in Rio not only the leading Latin-American specialists in these branches of surgery but also distinguished North American and European specialists who will attend as official guests of the combined Congress. The headquarters of the Congress will be at the world famous Hotel Quitandinha which is situated in the mountains near to Rio de Janeiro. Here, in addition to ample accommodation for the delegates, there are many spacious rooms which will be most suitable for the Meetings.

After the Congress visits will be arranged to the medical centres of Brazil and to places of interest such as São Paulo, Bahia, etc. There will be programmes of social activities, sporting expeditions and visits to places of typical Brazilian scenes. The activities will include fishing trips, visits to historic cities and other places which hold special interest for foreign visitors. A detailed programme of these arrangements will be prepared as soon as possible for those who are interested.

The organisers would like to hear as soon as possible from those who propose to attend the Congress so that the approximate number of delegates may be estimated. They would also like to know whether delegates will be accompanied by members of their families so that the necessary arrangements may be made.

Those who wish to present papers during the Congress should have sent the title of the paper to reach the president of the Congress not later then December 31, 1952. A typewritten résumé of the papers (in duplicate) must be sent to arrive not later than May 30, 1953, otherwise it will not be possible to include the title in the scientific programme or to allot the necessary time for presentation of the paper during the Meetings of the Congress. Further details of the organisation of the Congress will be published later. The president of the Congress and of the Brazilian Society of Orthopaedics and Traumatology is Dr Oswaldo Pinheiro Campos, of Rio de Janeiro. Other members of the Central Organising Committee include: Vice-president, Orlando Pinto de Souza; Co-ordinator, Luthero Vargas; Secretaries, Ricardo Luiz Ferreira da Costa and Marino Lazzareschi; Treasurer, L. Figueiredo; Technical Secretary, Jorge Beral Sardinha; Social Secretary, Dorothy Smith Campos and Roberto J. Taves. The address of the secretarial offices is Praça Marechal Floriano 31, Rio de Janeiro, Brazil.

INTERNATIONAL SOCIETIES

INTERNATIONAL SOCIETY OF ORTHOPAEDIC SURGERY AND TRAUMATOLOGY

The date of the Sixth Congress of the International Society of Orthopaedic Surgery and Traumatology, to be held in 1954 as announced in the last Volume of the Journal (Vol. **34-B**, page 720), has been changed. The Congress will now be held from August 30 to September 3, 1954.

Book Reviews

A TEXT-BOOK OF ORTHOPEDICS. By M. Beckett Howorth, M.D. Clinical Professor of Orthopedic Surgery, New York University Post-Graduate Medical School. 10 × 7 in. Pp. xxii + 1,110, with 463 figures. Index. 1952. Philadelphia and London: W. B. Saunders Company. Price 80s.

The writing and production of a text-book of orthopaedics is an ambitious and arduous undertaking to which comparatively few orthopaedic surgeons aspire, so that such books are not common, and the appearance of a new one is something of an event. Dr Howorth has set himself this task and has, I think, succeeded in producing a work of major importance, founded on more than twenty years' experience of the practice and teaching of orthopaedics.

The author describes his book as a study of the diseases and abnormalities of the neuro-musculo-skeletal system on a broad biological foundation, and the reader is therefore given first some account of the history of orthopaedics and then a description of the normal anatomy and physiology of the musculo-skeletal system, a very useful and unusual addition to a text-book of orthopaedics. This leads naturally to a detailed account of the methods of examination of orthopaedic

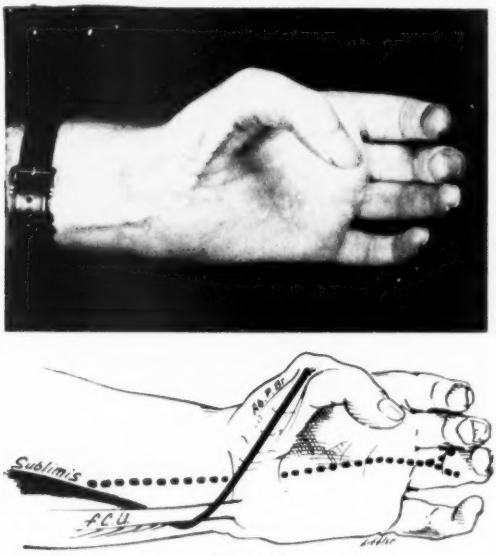

Fig. 136

patients and diagnosis. In the next section treatment is considered first on broad general lines. The author then turns to regional orthopaedics with special attention to disorders of the spine, hand, knee and foot, and finally to a detailed description of the important and the rarer orthopaedic disorders from every aspect.

The method of arrangement has eliminated overlapping, as much as is possible in a book of this magnitude. Classifications are simple, logical and based on the generally accepted terminology of disease. Though nothing essential has been omitted, some compression has been unavoidable, but the very full bibliography at the end of each section amply compensates for this. The bulk of the text is from Dr Howorth's own pen, but he has not hesitated to hand over the writing of some parts to specialist collaborators. The last section, by one of these, comprises nearly two hundred pages on neurology in relation to orthopaedic practice, and is complete enough to be almost a small text-book on neurology and neuro-surgery in its own right.

The book is beautifully printed and produced, and the numerous illustrations, both photographic and diagrammatic, are uniformly good. This book will certainly repay careful study by every young surgeon who intends to specialise in orthopaedics, though he would probably have to be content with borrowing it; it would be a valuable addition to the personal library of any established orthopaedic surgeon.—W. B. Foley.

LUMBAR DISC LESIONS. By J. R. Armstrong, M.D., M.Ch., F.R.C.S. Foreword by H. Osmond-Clarke, C.B.E., F.R.C.S. 9½ × 6½ in. Pp. viii + 228, with 56 figures and 21 colour plates. 1952. Edinburgh and London: E. & S. Livingstone Ltd. Price 42s.

This monograph is the product of the author's almost unique experience in the treatment of intervertebral disc lesions and of his untiring industry in reviewing the published work on every aspect of the disc problem. In it are brought together, for the first time in a British publication, all the important known facts about degenerative and mechanical disturbances of the lumbar discs. For the most part there will be wide agreement with the author's views; and those who might disagree in certain respects will have to admit that the discussion is fair and that the author's judgment is backed by the weighty evidence of his own experience.

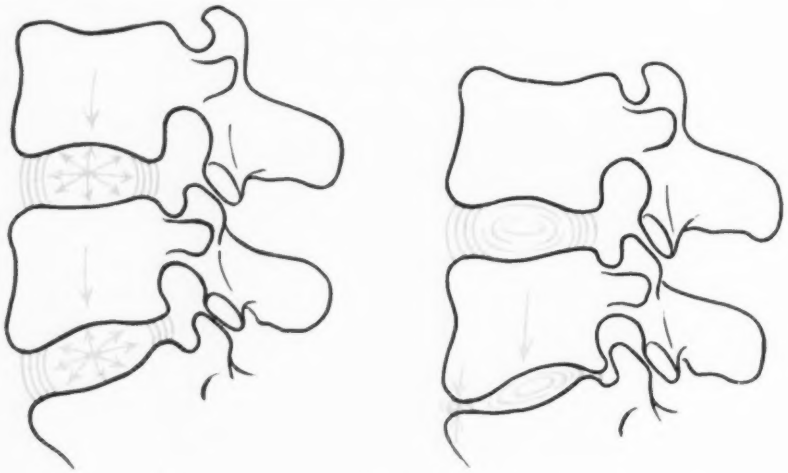

Fig. 34

Effects of nuclear destruction on intervertebral joint.

Normally compression forces are transmitted through the nucleus and distributed evenly over the annulus and cartilage end-plates (A). With nuclear destruction pressure is no longer evenly distributed (B). Narrowing of the space between the vertebral bodies is associated with incongruity of the articular surfaces of the posterior joints.

Every aspect of the problem of disc lesions is covered with admirable thoroughness yet without verbosity. The description of the pathology is on the whole convincing, though there are a few statements that are difficult to follow or to accept. The importance of the mechanical disturbance that may affect every component of an intervertebral joint in consequence of disc degeneration is rightly emphasised. The author also stresses that there are two distinct types of sciatic pain—the sharply defined "dermatogenous" pain caused by direct interference with a nerve root, and the deep, diffuse "scleratogenous" pain that is referred from a deranged joint or ligament. This useful knowledge is too often neglected in clinical practice.

The chapters on diagnosis and differential diagnosis are comprehensive and repay careful study. The emphasis is on clinical methods, and myelography is condemned except when there is real suspicion of a spinal neoplasm. The recommendations made for conservative treatment follow the usual lines. Many will share the author's doubts whether "head suspension" offers any advantage in applying plaster jackets. Some may feel that the gloomy picture of the results of conservative treatment is exaggerated.

Despite the author's sound advice on the unwisdom of hasty operation and on the importance of careful selection, one gets the impression that he has a rather pronounced inclination towards

operative treatment. He favours the lateral position of the patient, and there can be no argument about its advantages. About operative exposure, however, some surgeons will find themselves in disagreement with the author. Whatever may be believed about the significance of removing spinous processes and laminae, it can be argued with conviction that it is better to preserve them when it is possible to do so without impairing the safety or the success of the operation. Many surgeons of wide experience find that nearly always the abnormal disc material can be exposed and removed perfectly easily through a "fenestration," in which the spinous processes are undisturbed and only a sliver of bone is removed from the lower margin of the lamina; if special difficulty is encountered, the exposure may be widened at the expense of bone. Indeed the author weakens his advocacy of hemilaminectomy by recommending that, when two spaces have been explored unavailingly, a third space should be exposed by fenestration. If the fenestration approach is adequate in those circumstances, why not in others? Despite all this, however, the author's case for a wide exposure is presented very clearly, and the reader must form his own judgment.

The book is well produced, but it is exasperating to have to turn it on its side to look at the pictures.—J. C. Adams.

BONE TUMORS. By Louis Lichtenstein, M.D. Senior Pathologist, General Medical and Surgical Hospital, Veterans' Administration Center, Los Angeles. 10 × 7 in. Pp. 315, with 155 figures. Index. 1952. London: Henry Kimpton. Price 80s.

From 1940 to 1948 a remarkable series of pathological papers came from the Hospital for Joint Diseases in New York. The twelve most substantial of these appeared under the combined names of H. L. Jaffe and Louis Lichtenstein, and all except three were published in either the *American Journal of Pathology* or the *Archives of Pathology*. It is these papers which form the substance of Dr Lichtenstein's present book together with original additions relating to aspects of bone tumour pathology not dealt with in the older papers.

This book, excellent though it is, presents some curious features. It is not simply a congeries of reprints, nor is it all new writing. Some chapters, such as those on benign chondroblastoma, osteoid osteoma and chondromyxoid fibroma of bone, are completely rewritten forms of the earlier articles, but the impressive and lengthy chapters on Ewing's sarcoma (chapter 16) and multiple myeloma (chapter 17) are virtual transcriptions of the 1947 papers, differing from the originals only in a few minor textual alterations and sometimes in the order of paragraphs and sub-sections. Chapter 13 on chondrosarcoma is almost identical with the 1943 article except for some allusions to new cases which Dr Lichtenstein has since seen. No new references have been added. The oddest thing about these chapters is that the old text is, for some unexplained reason, illustrated by a mainly new set of photographs. Out of the twenty-six in the chondrosarcoma chapter, I could identify only seven that had appeared in the *American Journal of Pathology*.

These matters should not impair the book for the student of bone pathology, provided they are known to the prospective purchaser and to the researcher who might be tempted to use it as an original source. Dr Lichtenstein does not make it sufficiently clear in his preface how much verbatim reproduction of older texts is used. There is a real danger here. I have already heard the cytological criteria for malignancy in a cartilage tumour (reproduced on page 135 of this book) attributed to Lichtenstein (1952), whereas the correct attribution is to Lichtenstein and Jaffe (1943).

These things being said, this book can be wholeheartedly recommended to all who study bone disease—whether surgeons, pathologists, radiologists or radiotherapists—as one of the best on the subject of bone tumours. It is a slender volume, about the same size as a single issue of this Journal. It may cut a poor figure on the shelf among the massive tomes of other authors or syndicates, but books are not so much fat-stock to be marketed by weight. Dr Lichtenstein's papers with Dr Jaffe were characterised by a forceful and direct method of presentation and are well worth gathering together; in the new chapters Dr Lichtenstein demonstrates the same rational but bold treatment of his subject. His writing is obviously based upon a considerable personal experience. He writes well, and only occasionally, as in introducing his classification of bone tumours on page 17, does he tend to prolixity.

The author has decided opinions on the uncertainties of radiological diagnosis and on the propriety of histological biopsy before embarking upon radical surgery or irradiation. He opens his first chapter thus: "Despite the impression that still prevails in some quarters, there are no fixed formulas for the roentgen diagnosis of bone tumours, and most of the allegedly pathognomonic signs, while sometimes helpful, are often fallacious." He then proceeds for three pages to instance radiographic features which, though often held to be diagnostic, are neither constant nor specific to any one tumour. He more than once refers to the fallacy of assessing results of radiotherapy of alleged tumours or of tumours of alleged type which have never been histologically examined.

Dr Lichtenstein's classification of bone tumours is a histogenetic one at bottom, though pragmatic in effect. He tabulates tumours derived from cartilage-forming connective tissue, from osteoblastic connective tissue, from non-osteoblastic connective tissue, tumours of haematopoietic origin, of vascular origin, and so on. This classification has conformed with his actual experience of bone tumours; he has found it useful in clinical practice, for example, to distinguish osteogenic fibroma from non-osteogenic fibroma and sharply to contrast chondrosarcoma with osteogenic sarcoma. Theoretical objections to his classification therefore carry little weight; the purpose of pigeon-holes is surely to accommodate real birds, not mythical ones or extinct dodos. It may be noted that the adjective "osteogenic" is here firmly used in the sense of "bone-forming" and never in the corrupt sense of "arising from bone." Having one group of tumours of osteoblastic derivation, there was an opportunity for having another of osteoclastic derivation; but it is with a touch of regret that one notes the continued resistance of American authors to calling the giant-cell tumour of bone an osteoclastoma. It is grouped instead with tumours of non-osteoblastic connective-tissue origin, and on page 106 we read of "the ill-advised identification of these cells as osteoclasts"—but we must not be drawn into that argument now! Ewing's tumour is here classed as of mesenchymal connective-tissue origin, which is not much different from calling it reticulosarcoma—a name which seems to have been accepted by Lichtenstein when translated into French and used by Oberling but which must have a different shade of meaning for him in English, for on page 194 he says that the two neoplasms can be distinguished cytologically, "although the distinction is sometimes a rather subtle one."

The author is not so academic a pathologist that he scorns clinical features. Most of his chapters have a section devoted to clinical considerations, and on page 73 he even takes the trouble to recall that the bone pain of osteoid osteoma, though increasingly severe, is "often relieved by aspirin." Radiographs are beautifully reproduced and are well used; some are clinical radiographs, others are radiographs of pathological specimens, which are also well portrayed as gross specimens. Most chapters contain short but useful sections on treatment, where the advice given is founded on pathological precepts and on what is known of the life-history of each tumour; no operative or radiotherapeutic details are given.

Chapter 14 on osteogenic sarcoma is one of those not based upon a previous published paper. It is short but full of good points and superbly illustrated. It contains brief sections on Paget's sarcoma and on multicentric osteogenic sarcoma. Non-osteogenic fibrosarcoma of bone is considered in the fifteenth chapter. Many pathologists are reluctant to distinguish this tumour from osteogenic sarcoma, which has not yet started to form bone, but Lichtenstein claims (page 183) that "a neoplasm should be appraised in the light of what it does and what it actually looks like, rather than by any preconceived notion in regard to what it might do under other circumstances." This endeavour to separate on histological grounds one tumour from another, whenever their biological characters support such a separation, is in line with much of the original Jaffe and Lichtenstein work, such as their assault on the hotchpotch of giant-cell tumours and variants, a tale which is retold in the present volume. The book is particularly valuable because, in addition to bringing together all the old work from the Hospital for Joint Diseases, it continues the search for a useful and truthful understanding of bone tumours. The truth of the author's conceptions cannot be judged in our present state of knowledge, but with this book conveniently in our hands we can set about putting their usefulness to the test.

The final chapters deal with liposarcoma, chordoma, so-called adamantinoma of limb bones and metastatic carcinoma. The pleomorphic manifestations of secondary tumours in the skeleton are well stated and excellently illustrated. Non-neoplastic bone lesions which may be mistaken for tumours are dealt with in an appendix consisting of some three and a half pages of text and ten pages of fine photographs.—Douglas H. Collins.

CONGENITAL DYSPLASIA OF THE HIP JOINT AND SEQUELAE. By Vernon L. Hart, M.D., F.A.C.S. Assistant Professor of Surgery, University of Minnesota, Minneapolis, Minnesota. 8½ × 6 in. Pp. xv + 187, with 83 figures. 1952. Springfield, Illinois: Charles C. Thomas, Publisher; and Oxford: Blackwell Scientific Publications. Price 36s.

Congenital dysplasia is commoner than is generally supposed; its etiology is unknown; it can lead to subluxation or dislocation in the young, coxa plana in older children and osteoarthritic degeneration with "coxa magna valga luxans" in the adult. A pre-natal phenomenon, it affects the growth process of all the hip joint structures variously. Congenital dislocation is held to be uncommon during first six months of post-natal life, though it can occur occasionally in utero. As both congenital subluxation and dislocation are the sequelae of untreated—because undiagnosed—

dysplasia, the author very properly stresses the great importance of its early recognition: hence his plea to obstetricians, pediatricians, general practitioners, residents and midwives as they are most favourably placed to do so. The section dealing with the clinical features of the dysplastic hip is excellent and should greatly aid early diagnosis.

The treatment by the Frejka abduction pillow, which is well illustrated, is appealing in its simplicity. Serial radiographs of several patients show that the continuous pillow pressure between flexed abducted thighs can overcome the adductor contracture within two to three weeks and then allows a concentric reduction of the femoral head; the pillow splint produces an "active and functional immobilisation" until the acetabular roof is adequate, avoiding admission to hospital, preliminary traction, anaesthesia for reduction, and rigid splintage. Reduction is accomplished without an anaesthetic and without distress to the child, whose hips are then immobilised with a Frejka's pillow. How easy is the treatment of the dysplastic hip when compared with the full-fledged congenital dislocation as generally seen in this country at the age of one to two years! This is the author's message—the early diagnosis and treatment of the dysplastic hip before even subluxation, let alone dislocation, has occurred. Herein lies the way to better end-results. The text dealing with the background, the pathogenesis, the radiological features and the treatment has been written clearly, and the illustrations have been well chosen. The list of references is comprehensive.

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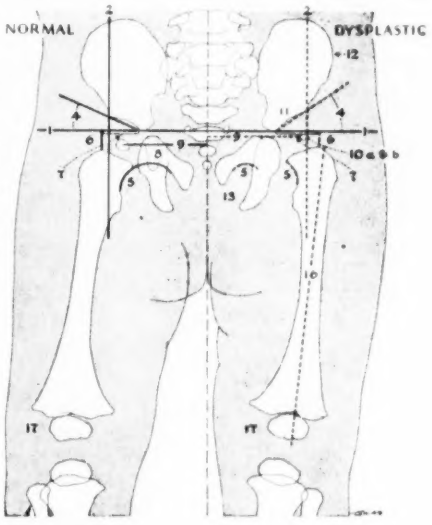

Figure 64. Observe:
1. The horizontal Y line (Hilgenreiner's line)
2. The vertical line (Perkins' line).
3. The quadrants (formed by lines 1 and 2).
4. The acetabular index (Kleinberg and Liberman).
5. Shenton's line.
6. Upward displacement of the femoral head.
7. Lateral displacement of the femoral head.
8. The U figure of tear-drop shadow (Köhler).
9. The Y co-ordinate (Ponseti).

Only minor criticisms can be voiced. One would disagree with the author's advice on page 69 where he recommends no surgical reconstruction of the acetabular roof unless prolonged conservative abduction treatment had failed in a child who develops a limp after several years of normal walking, and who has a sloping, inadequate acetabular roof. The "Sign of the Jerk" (Ortolani) is plugged: agreed that it is the audible, the visible and the palpable click on reduction of a subluxation or dislocation, it has been well known for ages to orthopaedic surgeons accustomed to manipulative reduction the world over. The book would be improved by an index.

The author has produced a most useful and readable book which should prove to be of inestimable value to all who are interested in this fascinating and difficult orthopaedic problem, the end-results of which leave much to be desired.—David Trevor.

CONGENITAL DISLOCATION OF THE HIP. By Julius Hass, M.D. Consulting Orthopedic Surgeon, Montefiore Hospital, New York City. 10 × 6½ in. Pp. x + 405, with 134 figures. Index. 1951. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications Ltd. Price 90s.

As the author points out in the preface, this exhaustive survey is justified because, although it is now fifty years since the first discovery of effective treatment, there is no unanimity about the best method to adopt. Much space is devoted in all sections of the book to the review of the development of ideas about etiology and treatment. All the mechanical factors in the different types of congenital dislocation are described, along with the importance attached to each by different authorities. The author's classification emphasises the difference between the typical dislocation in its varying degrees, the atypical or teratologic (that associated with other congenital abnormalities) and the isolated cases of known etiology. This section of the book is of particular interest and value. It serves to emphasise that our knowledge of this and other congenital abnormalities is far from complete, and that it is primarily based on mechanical factors, which

are perhaps secondary to influences on the developing foetus about which we have little knowledge or understanding. One point that is emphasised is that observations on the anatomy of dislocation of the hip in the foetus and the new-born are almost confined to the atypical or teratologic dislocations, and that reports on necropsies of typical congenital dislocation of the hip in new-born infants are extremely rare—amounting to about seven in the whole literature.

It is not surprising that the emphasis is on the classical methods of treatment. The author was associated with Lorenz for many years, and succeeded him at the University Orthopaedic Clinic at Vienna, and although he has faithfully reviewed the numerous methods of treatment evolved by many writers, including open reduction, he clearly holds that none of these methods is as generally satisfactory as that originally described by Lorenz. The various osteotomies and reconstruction operations are fully described, and some effort is made to assess their value.

The book adds nothing to our knowledge of this condition, but provides a valuable review of the subject as a whole and will be very useful to all those who have a special interest in this difficult subject.—J. C. Scott.

FRACTURES AND JOINT INJURIES. By Sir Reginald Watson-Jones, B.Sc., M.Ch.Orth., F.R.C.S., F.R.A.C.S. (Hon.), F.A.C.S. (Hon.). Orthopaedic Surgeon to His late Majesty King George VI; Director, Orthopaedic and Accident Service, The London Hospital; Senior Surgeon, Robert Jones and Agnes Hunt Orthopaedic Hospital; British Editor, Journal of Bone and Joint Surgery; Hunterian Professor, Royal College of Surgeons; Arthur Sims Commonwealth Travelling Professor of Surgery. 10 × 7½ in. Fourth edition. In two volumes (not sold separately). Vol. I, Pp. xxiv + 443, with 709 figures, many in colour. Index. 1952. Edinburgh: E. & S. Livingstone Ltd. Price £6 per set.

On reading through the first volume of the new edition of this magnificent work of Sir Reginald Watson-Jones the last few lines of Keats's Sonnet on Chapman's Homer come instinctively to mind:

"Then felt I like some watcher of the skies
When a new planet swims into his ken;
Or like stout Cortez when with eagle eyes
He stared at the Pacific—and all his men
Look'd at each other with a wild surmise—
Silent, upon a peak in Darien."

Silent! But the wistful silence of marvel and admiration is quickly replaced by the desire to share one's pleasure and proclaim the merits of this most admirable book. Yet no contribution of this consummate surgeon should need publicity, for he is one of the foremost of that group of men to whom Sir Arthur Keith gave the honourable name "menders of the maimed," and in the preface to this first volume of the new edition the author stresses the value of the human touch: "Important as recent scientific developments have been," he says, "it is still true to say that far more patients are cured by the art of medicine than by the science."

Had the son of Sirach who wrote the Ecclesiasticus been privileged to live his span of years two millennia later and shake hands with the author of *Fractures and Joint Injuries* he would assuredly have omitted much of the famous chapter wherein he writes of the physician as well as of the artificer and workmaster. While there is much that is appropriate, for example: "He will set his heart upon perfecting his works, And he will be wakeful to adorn them perfectly . . . All these put their trust in their hands; And each becometh wise in his own work"; the presage of the son of Sirach went sadly awry in respect to Sir Reginald when he wrote:

"They shall not be sought for in the council of the people,
And in the assembly they shall not mount on high;
They shall not sit in the seat of the judge,
Neither shall they declare instruction and judgement."

In an apologia the author takes pains to explain the long interval elapsing between the appearance of the third and fourth editions of "Fractures," although the third edition had indeed been reprinted in 1944 and again in 1946. But surely this lament bespeaks excessive zeal on his part, for a worthwhile book demands a longer gestation period than that which precedes the customary date for maieutic assistance in human pregnancy. Virgil spent seven years on the Georgics; Horace in the *Ars Poetica* advises the would-be poet to put aside his manuscript for nine years before giving his verses to the world, while fourteen years elapsed between the appearance of the first and eighth volumes of Gibbon's *Decline and Fall of the Roman Empire*, and almost a quarter of a century passed between the time when this great masterpiece of history was first conceived among the antiquities of Rome and the year in which the final volume saw the light of day.

The heat of artistic emotion is always convertible into a force of constructive order, and "Fractures" is the creation of one who is a great artist. Not for "Reggie" the despairing thoughts in the night watches such as came to Virgil, prompting the letter to the Emperor Augustus: *Tanta incohata res est, ut paene vitio mentis tantum opus ingressus mihi videor*—"this huge work is begun; I think myself almost mad to have embarked upon it." No! our author is borne along and carries us with him by reason of the glowing athanor of his own infectious energy and enthusiasm.

Much has been added in this new edition; there is an abundance of illustrations, some of which have been culled from the skiagraphic and other collections of his surgical brethren all over the world—he is indeed an international figure—and to this new edition the inscription on the headquarters of the Research Council in Ottawa seems not inappropriate: "The more thou searchest, the more shalt thou marvel."

FIG. 195

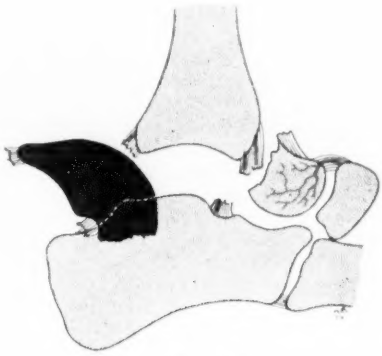

FIG. 196

Fracture of the neck of the talus does not interfere with the blood supply (Fig. 195). If the body of the talus is also dislocated backwards, it undergoes necrosis (Fig. 196).

Where all is so admirable it seems invidious to select any section of the book for special praise, but that dealing with pathological fractures is a mine of information. "Traumatic surgery cannot be practised apart from general orthopaedic surgery; surgeons who treat fractures must be alert to the many possible implications of bone injury, and particularly to the recognition of dystrophies of bone with a predisposition to fracture." The observations on the terminology of traumatic myositis ossificans recall to the memory of the reviewer a discussion over forty years ago in which three future Presidents of the Royal College took part—Makins, Godlee and Bowlby—and which might have been thought to give the name its quietus!

It is strange that no mention is made of the frequency of hydatid disease in Greece and Cyprus although, according to some, the incidence of the malady in that island is second only to that of Uruguay; and the curiosity of the reviewer, whose attention has been distracted in his later years to tumours around the pelvis and hip joint, has been whetted to know whether the extent of the hydatid disease demonstrated in the skiagram of the patient in the Cape Town hospital permitted extirpation of the malady by "hindquarter" amputation.

The arrangement of the competent bibliography, page by page, is a great convenience to the reader and, along with the index of names at the end of the book, will often recall memories of friendships with surgeons of to-day as well as with those who have "passed on."

It has been said that "speech is the golden harvest that followeth the flowering of thought," and those who have listened to the oratory of Sir Reginald and who must inevitably have read his previous literary works will be prepared for the attractive, impeccable English in which this new edition is written. Scientific works do not demand, nay properly lack, the mellifluous language of

> "Old Virgil, who would write ten lines they say,
> At dawn, and lavish all the golden day
> To make them wealthier in his readers' eyes,"

and there is very little in this work which raises an eyebrow or directs a hand to a blue pencil. Perhaps only a pedant takes umbrage at "human" being employed as a substantive, particularly since the Oxford Dictionary admits of this use, with the comment, "now chiefly jocular or

affected "! and there is also one very lengthy sentence with an ultra-Dickensian plethora of semicolons, at which even the breathless author himself laughs, and he will doubtless laugh the more heartily that an old friend has been impish enough to comment on it.

This is a book which must be in the hands not only of every surgeon called upon to treat injuries but of every surgeon everywhere. It is the work of a Master Surgeon, a vital and dynamic personality, a great friend and a great gentleman; it is a work that brings honour to the surgeons and surgery of Britain, to the surgery of the English-speaking races, nay to surgery wheresoever it be practised, regardless of frontiers, *per orbem terrarum*.—Gordon GORDON-TAYLOR.

ARCHIVIO "PUTTI" DI CHIRURGIA DEGLI ORGANI DI MOVIMENTO. Volume I. Edited under the direction of Professor O. SCAGLIETTI. Director, Clinica Ortopedica dell'Universita, Istituto Ortopedico, Toscano, Florence. $10\frac{1}{2} \times 8$ in. Pp. 387, with 440 figures, 14 in colour. Bibliography. Index. 1951. Firenze: Edizioni Scientifiche dell "Istituto Ortopedico Toscano." Price in Italy L.4000,. Price for foreigners $10.00

It is not possible for any book review to express adequately the very high standing of the late Vittorio Putti, or to make any worthwhile reference to the contribution made to orthopaedic surgery by this very great man. His impact on our branch of surgery is being felt in South America, among other places, as a dymanic force which will probably mould the whole nature of South American orthopaedics. In his native Italy his influence decided the shape, and even the conventions, of orthopaedic practice. His great learning, his skill as librarian and as a collector of medical books, and his love of orthopaedic knowledge have become almost legendary. It is, therefore, more than fitting that a new Italian publication on orthopaedic surgery should be established as "Putti's Archives" and it is particularly pleasing that the first such volume should bear comparison very easily with the "Archives" that were published in honour of the great surgeons and great pathologists of the last century. This volume, directed by one of Putti's leading pupils, Oscar Scaglietti, is well worthy of its object. The papers it contains are, on the whole, written in clear Italian that is by no means difficult even to the foreigner. They are of considerable interest. Among them, Scaglietti himself produces his reasons for preferring bone suture to what we in Britian regard as "internal fixation," Coronedi reports the study of 282 fractures of the patella, Sassoli of sixteen fractures of the neck of the talus, and Marega gives a thoughtful account of subclavian aneurysm in a case of cervical rib and of its treatment by endoaneurysmorrhaphy. The reviewer was also particularly interested in a paper on osteogenesis imperfecta by de Angelis Effrem, but it is invidious to single out individual contributions to this collection which so strikingly expresses the vivid and active nature of Italian orthopaedic thought to-day. The volume concludes with an adequate bibliography on world orthopaedic literature for the first half of 1950. Your reviewer will be only one of many British surgeons who will await subsequent volumes of these Archives very keenly.—D. Ll. GRIFFITHS.

POST-GRADUATE LECTURES ON ORTHOPEDIC DIAGNOSIS AND INDICATIONS. By Arthur STEINDLER, M.D., F.A.C.S. Professor of Orthopedic Surgery, State University of Iowa. Volume III. Section A: Tuberculosis of the Skeletal System. Section B: Osteomyelitis. $10\frac{1}{2} \times 7$ in. Pp. xiv + 284, with 255 figures. Index. 1952. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. Price 63s.

The third volume of Professor Steindler's Postgraduate Lectures is devoted to two topics—skeletal tuberculosis and osteomyelitis. His presentation of the regional manifestations of tuberculosis of bones and joints is less of a personal document than usual, and more particularly in his quotations from the older statistics relating to cure and functional recoveries. In Pott's paraplegia he is an advocate of operative intervention when there is no change in the syndrome after four to eight weeks' conservative treatment, but the operation he has in mind is laminectomy. The technique of antero-lateral decompression, a procedure still under trial in this country but often dramatic in its results, is not discussed. His attitude towards the use of spinal fusion is conservative, and he believes that its chief virtue is in adults in whom the affected area of the spinal column remains incompletely consolidated for many years after the so-called healing stage. In tuberculous arthritis of the hip Professor Steindler favours combined intra-articular and extra-articular arthrodesis. His account of the sequelae of hip disease omits any reference to the grave complication of premature fusion of the knee epiphyses during prolonged immobilisation.

The section on osteomyelitis gives us more of the touch of the master. He makes one of his characteristic wise statements when he emphasises the distinction between necrosis and

sequestration. He is satisfied that, although the use of the modern antibiotics has revolutionised the outlook in acute osteomyelitis, there is still a place for drainage in certain circumstances. An unusual amount of space is devoted to osteomyelitis of the spine and bony pelvis, which have been the subject of special studies in the Steindler clinics. The account of these and other uncommon types of osteomyelitis will be invaluable for reference purposes.—Harry PLATT.

CAUSALGIA. By Frank H. MAYFIELD, M.D. Assistant Professor of Clinical Study, College of Medicine, University of Cincinnati. 8½ × 5½ in. Pp. 65, with 12 figures. Index. 1951. Springfield, Illinois: Charles C. Thomas, Publisher. Oxford: Blackwell Scientific Publications. Price 16s. 6d.

This slender monograph is one of the series of American Lectures in Neurosurgery which is being issued under the general editorship of Drs de Bakey, Spurling and Barnes Woodhall. It reports the author's experience with 105 cases of causalgia arising entirely during his service in the American Armed Forces. Most he has already published elsewhere. The monograph gives an excellent, succinct account of our present knowledge of causalgia and of its treatment. In Mayfield's series the nerve injury was incomplete in every case and he does not attempt to discuss the difficult problem posed by the occasional incidence of causalgia after complete nerve section. He also tells us nothing about the equally difficult problems of "cold pain" in injuries to fingers. Despite all the many theories of the cause of this syndrome Mayfield has to admit the possibility that afferent pain impulses are transmitted by the sympathetic, a phenomenon which is, after all, quite well recognised for visceral pain. The book contains very good diagrams of the posterior operation for sympathetic denervation of the upper limb and of lumbar sympathectomy as it is usually performed. There is one peculiar spelling mistake on page 5, and the name "Sudeck" receives an unusual spelling. Otherwise there are no faults to find.—D. Ll. GRIFFITHS.

LA SPONDYLARTHRITE ANKYLOSANTE. By J. FORESTIER, F. JACQUELINE and J. ROTES-QUEROL. 10 × 6¼ in. Pp. 312, with 143 figures. Index. 1951. Paris: Masson & Cie. Price not quoted.

This monograph should be studied by every physician, radiologist and surgeon particularly concerned with the care of patients suffering from ankylosing spondylitis. Three experienced physicians review over 400 personal cases observed through long periods, a number for more than twenty years. Not only are the etiology and clinical course of the disease described; but also the symptoms, the physical signs, the radiographic appearances, and the pathology as related to each joint are elaborated in expansive detail. One feature only will surprise British readers and that is the small emphasis placed on radiotherapy, perhaps because of the low dosage employed which may well have given the authors an unduly pessimistic view of prognosis. The book is liberally illustrated with reproductions of radiographs of outstanding quality which are a credit to both the authors and the publishers.—Philip WILES.

THE IMPORTANCE OF RICKETS IN CHILDHOOD AS A CAUSE OF SCOLIOSIS IN ADULT AGE. By Malte BRUNK. 9 × 6 in. Pp. 114, with 3 figures and 26 tables. Acta Orthopaedica Scandinavica Supplementum No. 9. 1951. Copenhagen: Ejnar Munksgaard. Price Dan. kr.10.

This monograph represents a very determined attempt to assess the importance of rickets in the etiology of scoliosis. That this particular problem presents many difficulties is obvious—otherwise it would have been solved long ago. The two main difficulties that confronted the author were the scarcity of untreated rickets and the impossibility of being certain that none of those in the control series had suffered from some degree of rickets. The general thesis is very well developed, beginning with an extensive review of the literature of the etiology of scoliosis. One hundred and forty-five subjects of rickets were available for analysis. The control series seems to have been rather highly selected (consisting of girls from a physical training school, army recruits, and a small number of hospital servants). It is disappointing—but, with all the difficulties, perhaps not altogether surprising—that the conclusions are indefinite and a little uncertain. "It is thus probably justified to conclude that rickets of such severity as to cause skeletal deformation may be a cause of scoliosis, and that such scoliosis is localised to the thoracic spine, probably to the middle and lower part."

Brunk has done a great deal of work on the problem. The disappointing character of his conclusions enhances the value of the work, because, with less care and less regard for statistical values, it would have been possible to present dogmatic statements which might have been quoted in many places and even have delayed progress toward an understanding of the etiology.—J. C. SCOTT.

CERVICAL NERVE ROOT COMPRESSION RESULTING FROM DISC DEGENERATION AND ROOT-SLEEVE FIBROSIS. By Ragnar Frykholm from the Department of Neurosurgery, Serafimerlasarettet, Stockholm. 9½ × 7 in. Pp. viii + 149, with 23 figures and 6 tables. 1951. Stockholm: Acta Chirurgica Scandinavica (Supplementum 160). Paper cover. Price not quoted.

Attention directed to the incidence and significance of cervical disc protrusions and their sequelae is a timely contribution. The author has presented an exhaustive and orderly study of cervical disc and nerve root pathology based on some thirty operative cases. The clinical picture of nerve root compression has been clearly shown. The causes of prominent symptoms such as pain have been carefully discussed. The etiology of pain having a nerve root pattern in the absence of gross protrusion of the disc has been extensively investigated. Dr Frykholm has explained such symptoms on a constricting fibrosis of the nerve root sheath. This root-sleeve fibrosis has been presented as a much more common cause of upper extremity pain than has previously been appreciated. Differential diagnosis, an outline of treatment indications and routine, and a description of the hemifacetectomy approach are included. The study is completed by detailed analysis of the thirty cases. The subject has been thoroughly covered with sufficient historical and clinical information to keep it interesting and practical. The concept of root-sleeve fibrosis is provocative. The book is recommended to all particularly concerned with upper extremity pain.—James E. Bateman.

LEG AMPUTEE: PRE-PROSTHETIC TRAINING. By Signe Brunnstrom and Donald Kerr. Rehabilitation Series: No. 3. 8½ × 5½ in. Pp. v + 44, with 72 figures. 1951. New Jersey: The Kessler Institute for Rehabilitation. Paper cover. Price $1.00.

This booklet is intended for the guidance of leg amputees themselves and of those responsible for post-operative care and rehabilitation during the period between amputation and the supply of a limb. It might well be read by all house surgeons and particularly by those attached to orthopaedic and physical medicine units. It stresses the importance of an early start to rehabilitation, and of obtaining the full co-operation and interest of the patient in his own welfare and in preventing flexion and other deformities of the stump. It follows very closely methods used here for many years and differs only in minor details from similar publications issued by Roehampton Limb Fitting Centre. It is well written and the illustrations are good.

Attention to details, such as the correct position of the stump while in bed and simple bed exercises, is stressed. British surgeons would consider traction rarely necessary after a planned below-knee amputation. The stump bandage, to dissipate oedema and encourage shrinkage, should be worn by night as well as by day until a limb is fitted. In bandaging an above-knee stump a descending spica is less likely to promote flexion deformity than an ascending spica. The selection of crutches and the best way of using them is well described. Much useful advice is contained in the paragraphs on strengthening the opposite leg and on general reconditioning. The stump exercises advocated can easily be done at home. The correct handling of the patient is important, not only physically but psychologically, and the firm belief that the loss of a leg is an incident and not a calamity must be fully understood by the patient and his relatives. Altogether the booklet is a useful addition to the library of a Rehabilitation Department and is worth reading.—T. Ritchie.

THE SCIENCE AND PRACTICE OF SURGERY. By W. H. C. Romanis, M.A., M.B., M.Chir. (Cantab.), F.R.C.S. (Eng.), F.R.S. (Edin.). Senior Surgeon and Lecturer on Surgery, St Thomas's Hospital; and Philip H. Mitchiner, C.B., C.B.E., T.D., M.D., M.S. (Lond.), F.R.C.S. (Eng.), D.Ch. (Durham). Hon. Surgeon to H.M. The Queen, Consulting Surgeon, St Thomas's Hospital. Ninth edition. Volume I—General Surgery. Volume II—Regional Surgery. 9½ × 6 in. Pp. xiv + 1,891, with 728 figures. Index. 1952. London: J. & A. Churchill Ltd. Price 32s. (Vol. I); 36s. (Vol. II).

The first edition of this popular text-book written by two outstanding teachers achieved immediate and well deserved success. At that time, when surgical specialisation was but a tiny shadow on the landscape, it was possible for two men to have personal experience of almost the whole of surgery and deal with it authoritatively. But times have changed and surgical knowledge has grown. This is recognised in the ninth edition to the extent that the surgery of the eye, and of the ear, nose and throat, and plastic surgery, and the sections on venereal diseases, radiodiagnosis,

radiotherapy and anaesthetics have been re-written or revised by specialists in these subjects. In the preface to this edition it is stated that "the specialist is far too prone to try and crowd into the undergraduate teaching technical details of a specialty which are the concern of the postgraduate." This may well be the case at times, but it cannot apply to such subjects as "shock" and "burns" which the authors treat with but scant reference to modern work; most certainly it is no justification for presenting a great branch of surgery, which occupies nearly one quarter of the entire text, as it was a quarter of a century ago, when, in reality, its whole practice, indeed its very spirit, has changed. If this is what present-day undergraduates are to be taught of orthopaedic surgery, out-patient departments will continue to be crowded with patients whose general practitioners should have been competent to advise them. It is hoped that in the tenth edition much old wood will be pruned from many sections and that a surgeon who has specialised in orthopaedics will be invited to *re-write* chapters 12 to 22 of volume I.—Philip Wiles.

ROSE AND CARLESS' MANUAL OF SURGERY. Edited by Sir Cecil Wakeley, Bt., K.B.E., C.B., LL.D., M.Ch., D.Sc., F.R.C.S., F.R.S.E., F.R.S.A., F.A.C.S., F.R.A.C.S. Fellow of King's College, London. President of the Royal College of Surgeons of England. Assisted by Eighteen Contributors. Eighteenth edition. $9\frac{1}{2} \times 6$ in. Pp. xix + 1,471, with 1,007 figures, 18 in colour. Two volumes. Index. 1952. London: Baillière, Tindall & Cox. Price 63s. the set.

It seems harder to keep an old book up to date than to write a new one. It goes against the grain to throw away old clothes however shabby they have become, and this is just what an editor of a text-book for students must do. Judged by these standards the eighteenth edition of this famous text-book is a failure. The book has a more modern appearance but it has not discarded enough. Does anyone nowadays "bipp" a wound? If reference must be made to "bipp," the reader should be told what it is and how it is applied. The author of a text-book should be a kindly man; he should spare his readers and not burden their memories with useless facts. For example, the enumeration of the possible causes of hernia does no one any good; it helps neither in prevention nor in cure. No two people will agree on the relative importance of a subject, but two pages devoted to the methods of operating on tumours of the pineal body is excessive. The chapters on orthopaedic surgery might have been written years ago with their insistence on rickets as a cause of deformity. It is not to be expected that a general surgeon should be *au fait* with what the specialist surgeon is doing, but surely it is wrong to teach a student to diagnose a fracture of the neck of the femur by examining Nelaton's line. In spite of its many failings the book does give a comprehensive picture of surgery. It includes everything; for example, the chapters on eyes and ears are admirable for an undergraduate. To criticise is easy, but is there a better book to recommend to students?—George Perkins.

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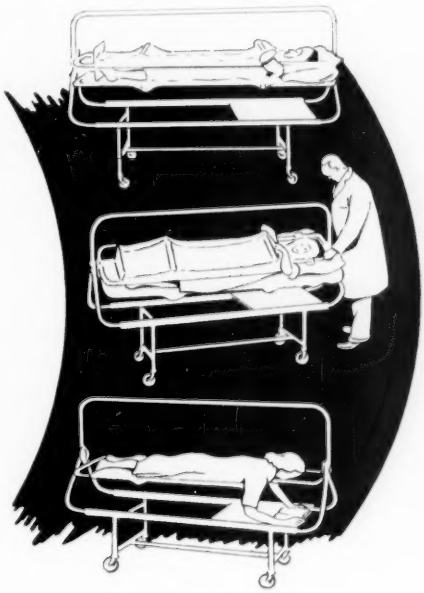

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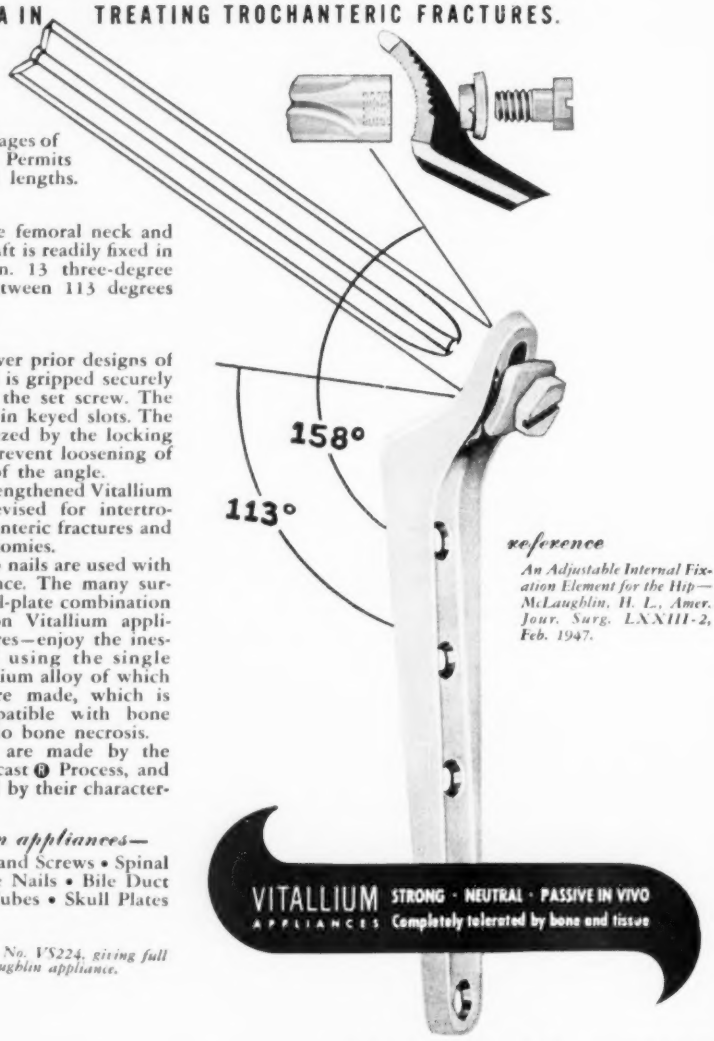

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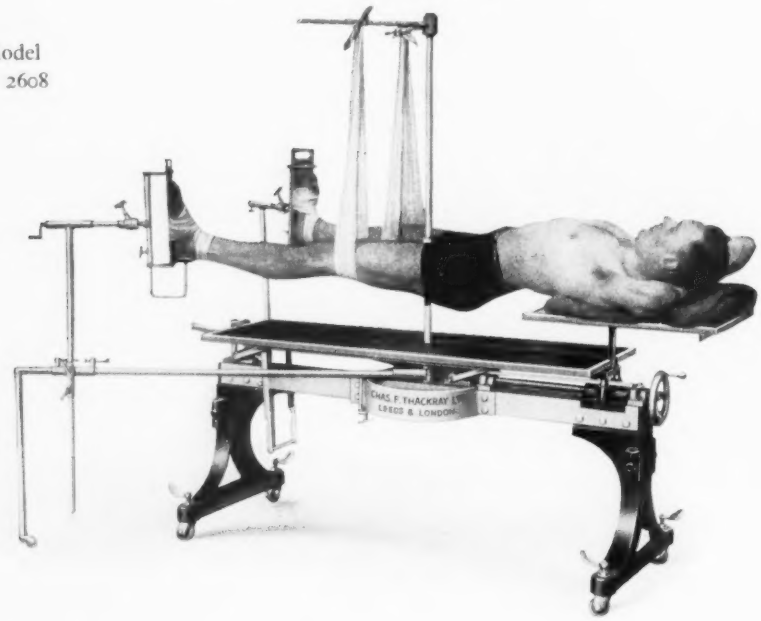

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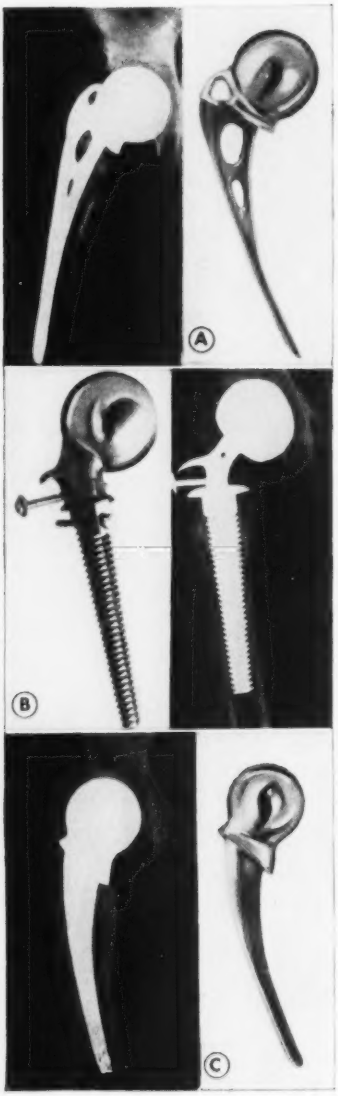

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[1] *Lancet, 1951, I, 210*

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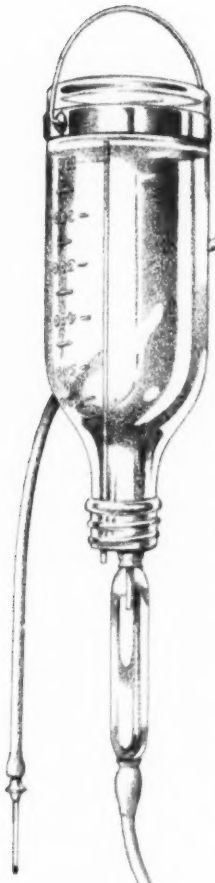

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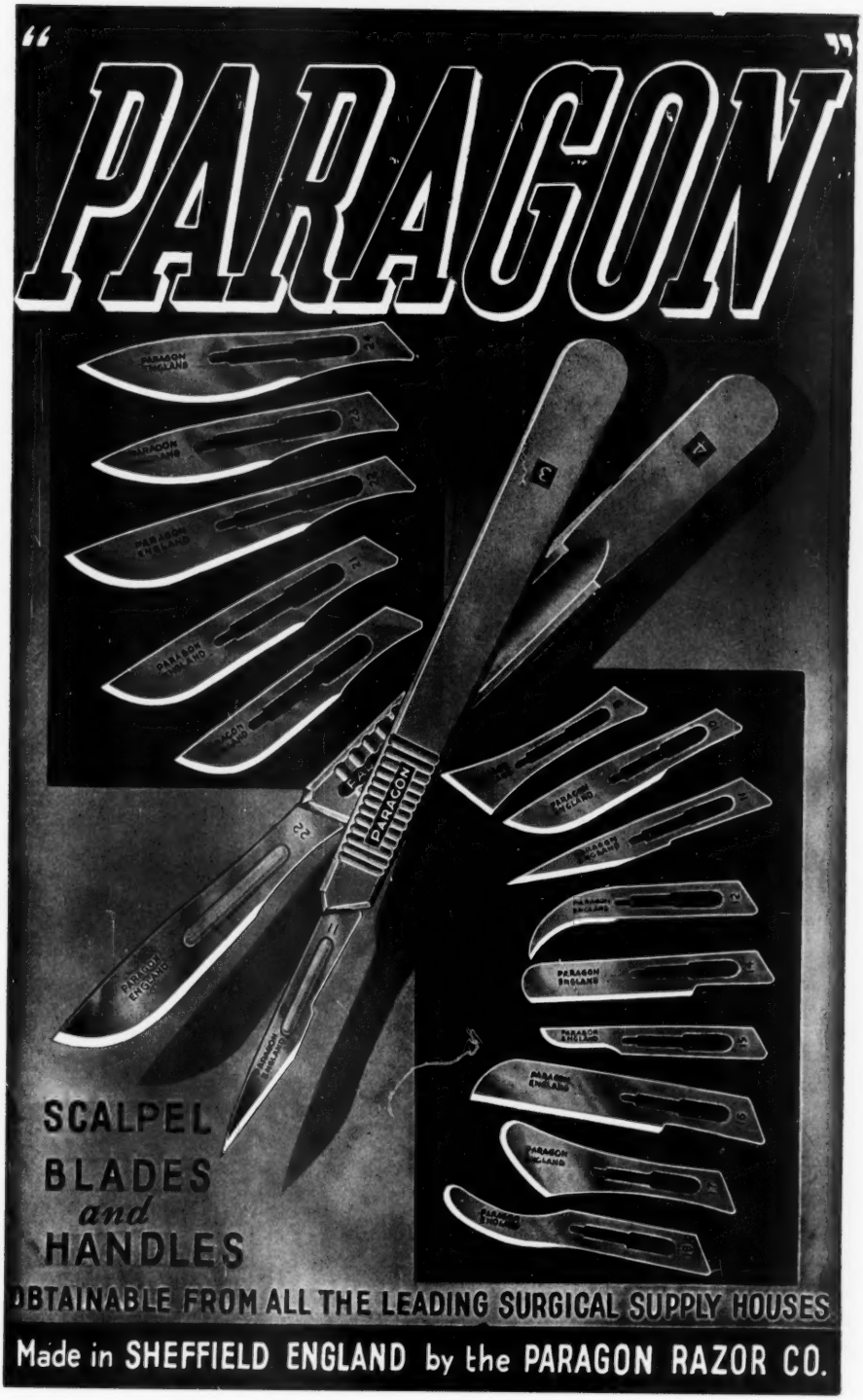
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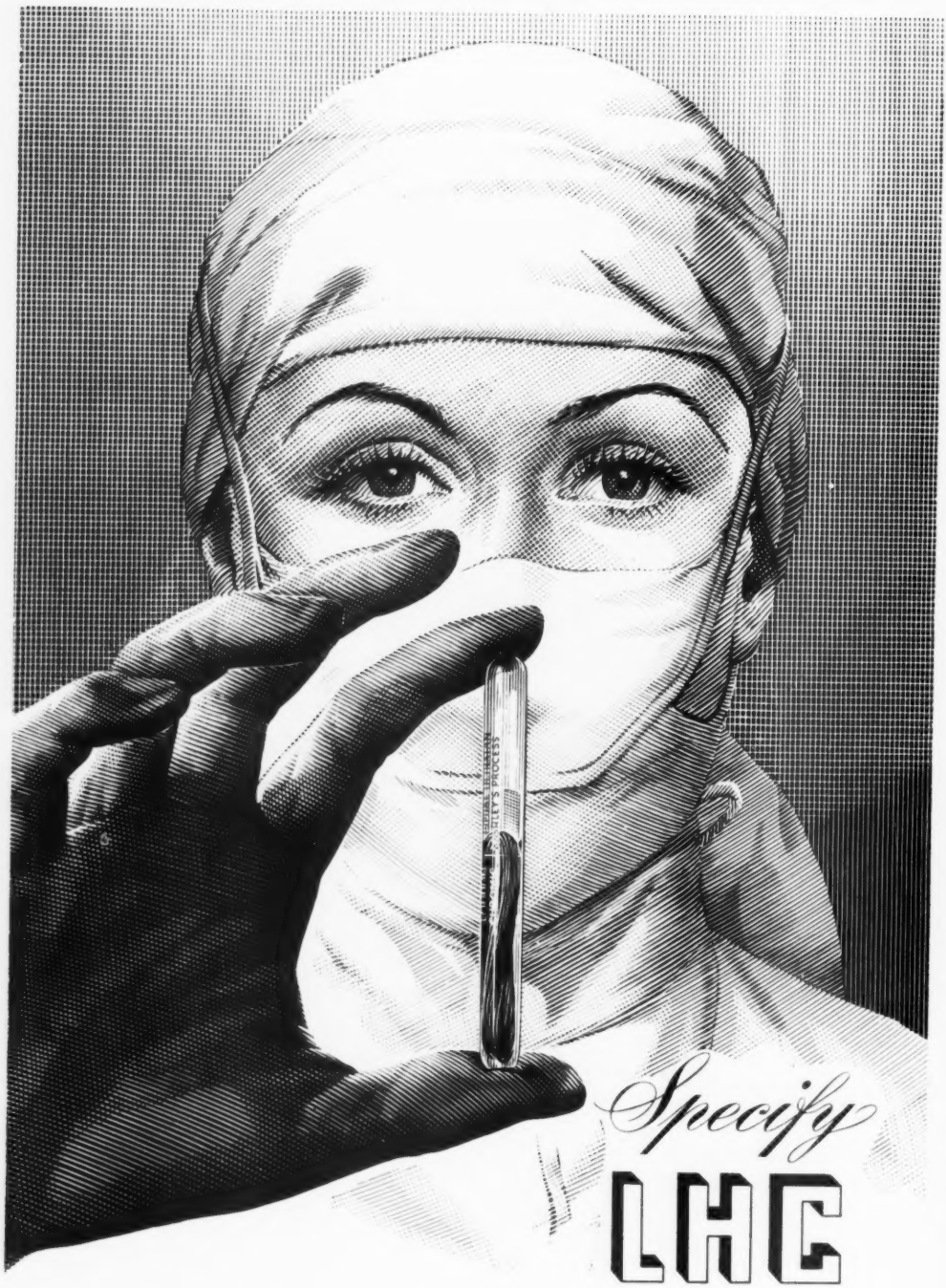

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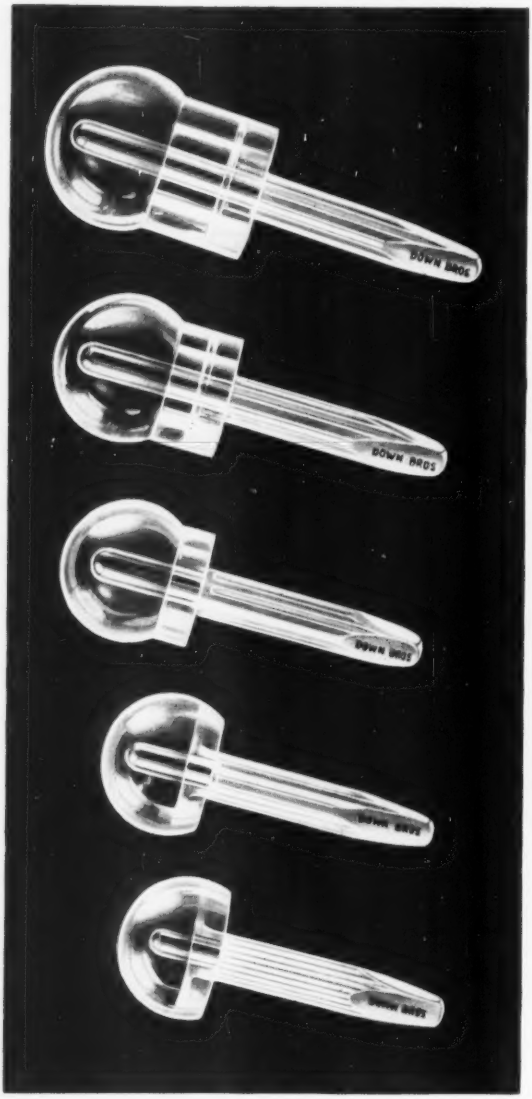

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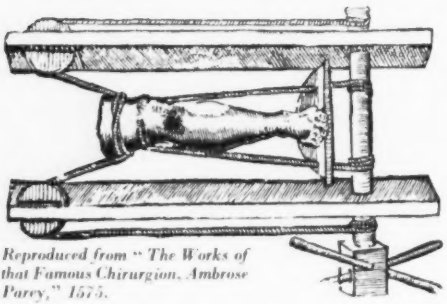

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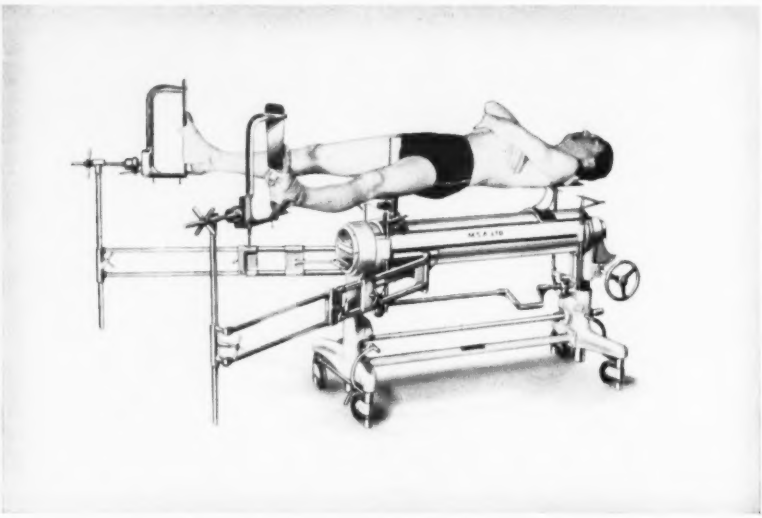

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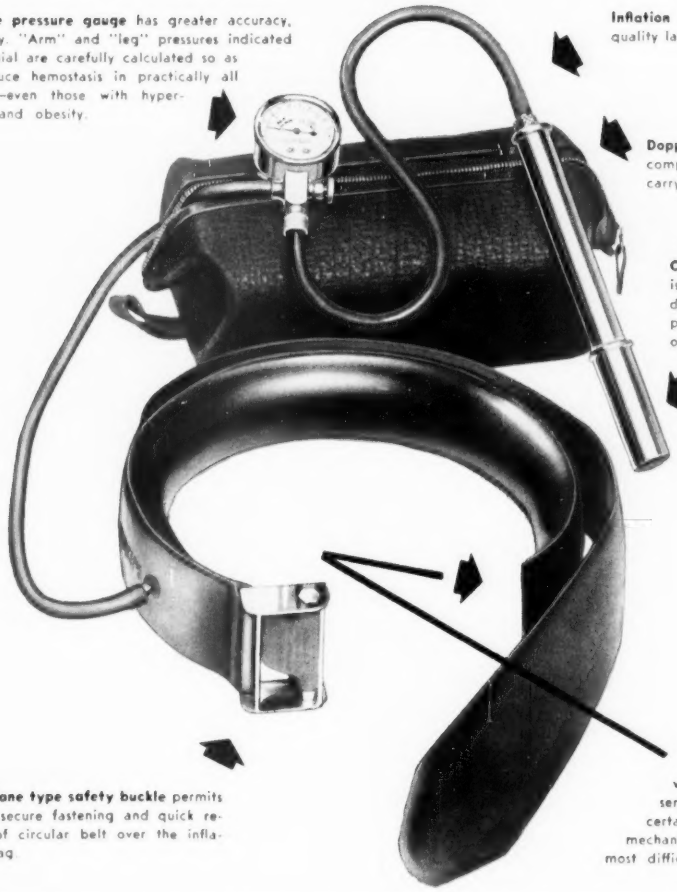
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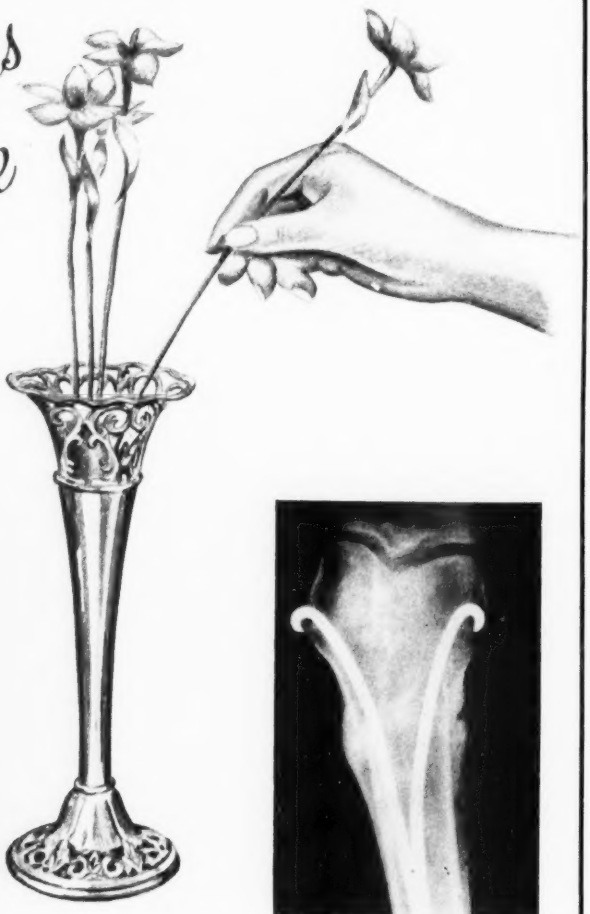

Ref. Rush, L. V., Dynamic Factors in Medullary Pinning of Fractures, *The American Surgeon*, Sept., 1951.

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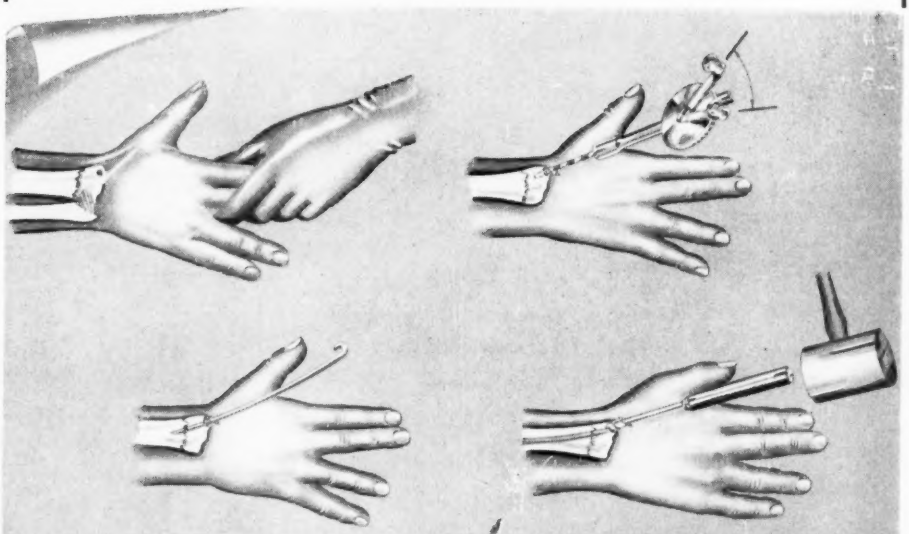

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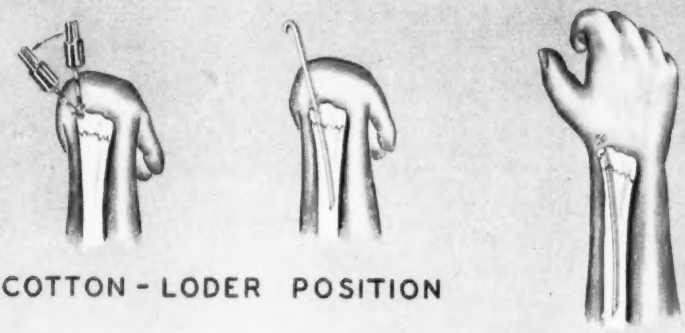

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